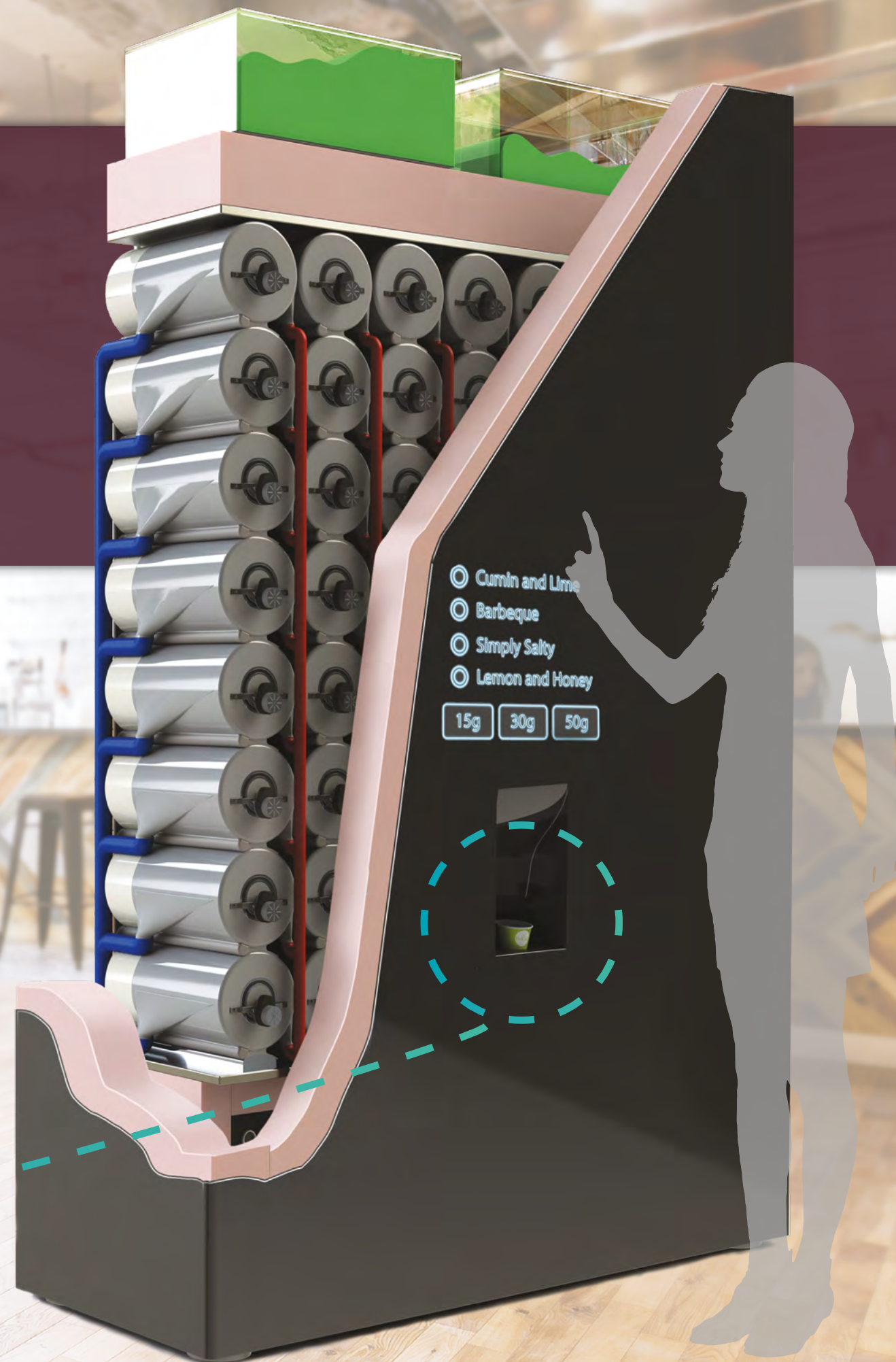




Roasted crickets vending machine

Design Journal



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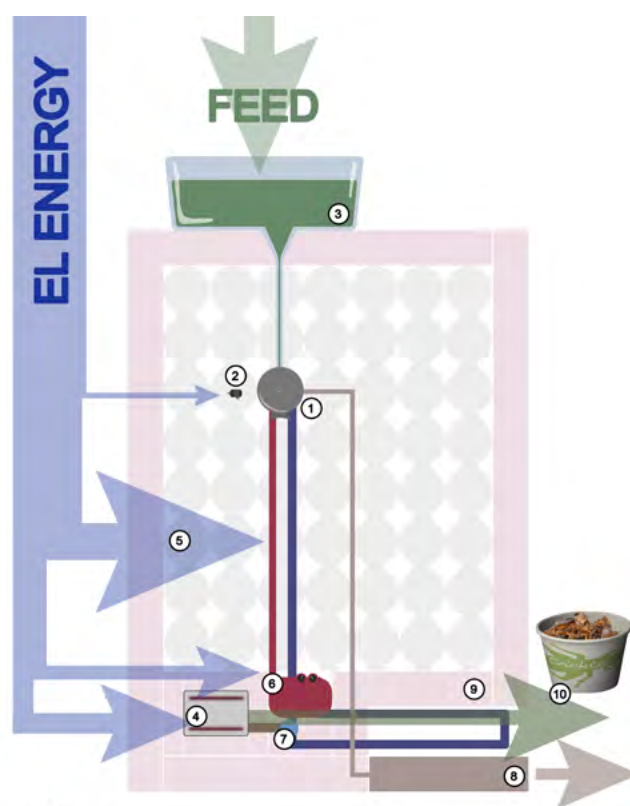
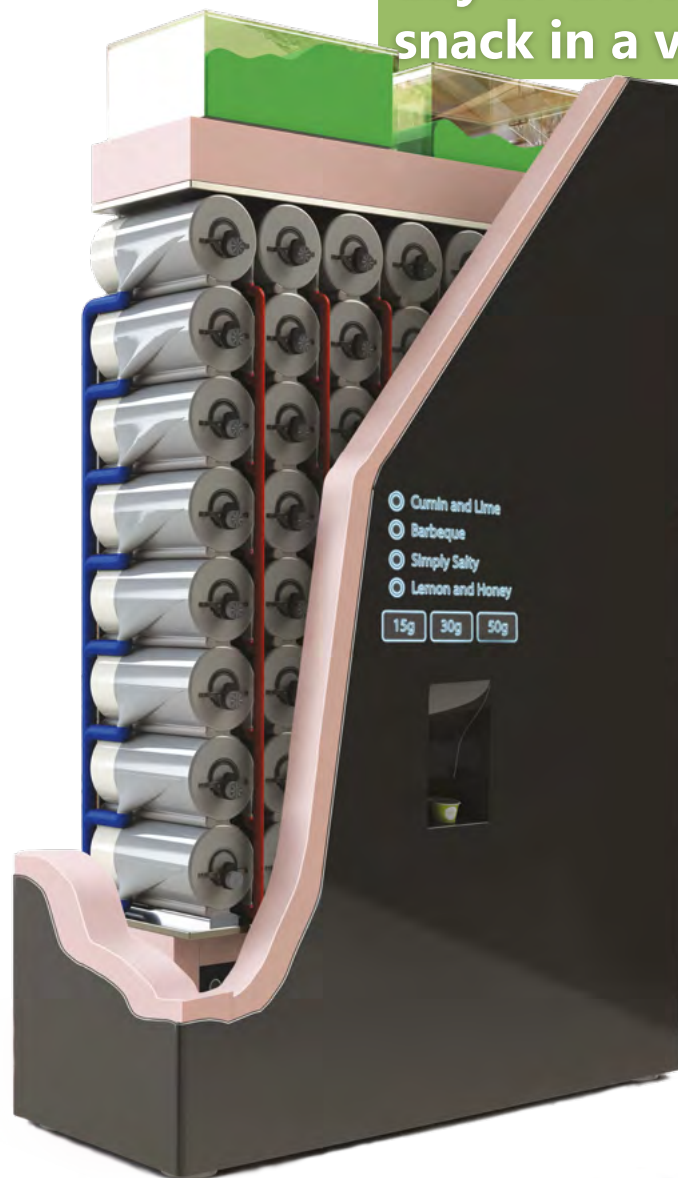
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There's not much to say to sum up this chapter. I think the contents say it all :)

Executive summary

What

The criCup vending machine produces, processes and dispenses 1kg of crickets a day in the form of a healthy snack in a variety of flavours.

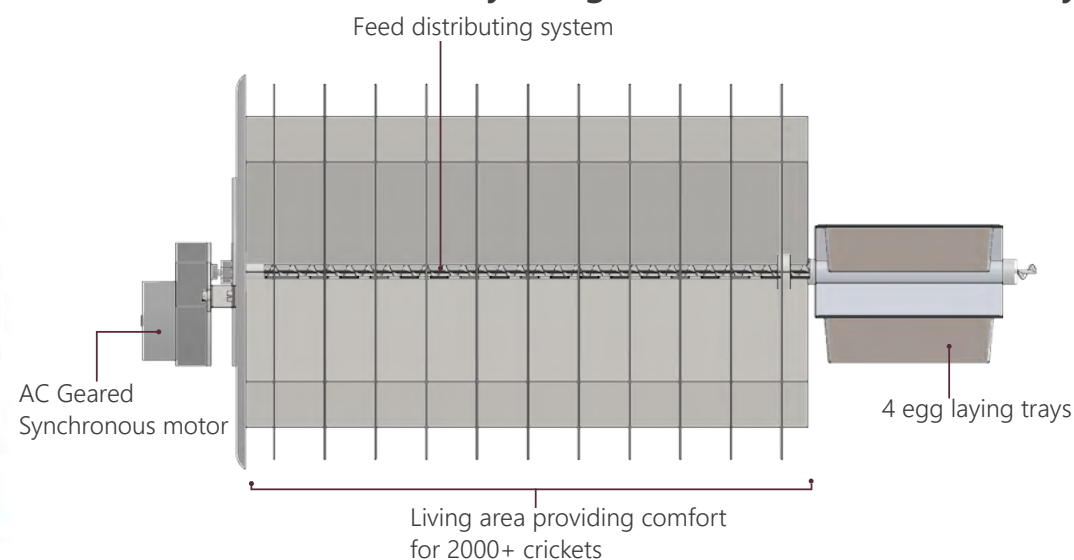
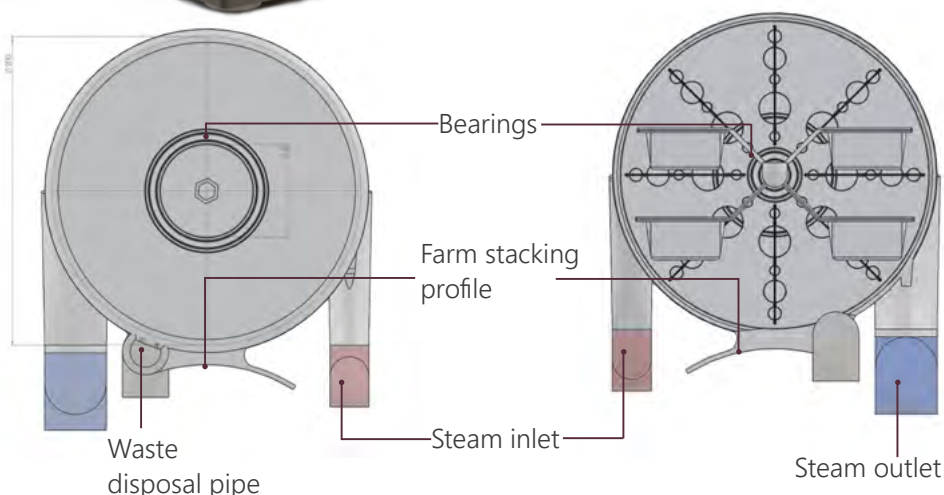


- | | |
|---|--|
| ① Unit farm, 2000 crickets x 56 | ⑥ Boiler and hot pipe |
| ② Synchronous motor, 1RPH x 56 | ⑦ Filter separating crickets and water |
| ③ Feed storage tank, 1 month x 2 | ⑧ Waste |
| ④ Oven, 220°C, 6 minutes | ⑨ Polyurethane Foam |
| ⑤ Heater for farm area of 1m ² | ⑩ 0.5kg roasted crickets a day |



How

56 cricket farms, carefully designed for maximum efficiency.



Where

In Social context where one can find other vending machines i.e. Sport Centres, Supermarkets, Offices.

Why?

The western world needs to start incorporating alternatives methods of getting their protein.

Who?

18-40 years old who are curious and environmentally responsible.

Acknowledgements

There are so many people I want to thank for supporting me and helping with the project.

Fellow classmates Andreas, Christian, Georgie and Kat for weekly meetings providing feedback and generating new ideas. Wouldn't be here without you, guys!

Cyril from Patisserie Maximme and Nick from Crunchy Critters for their time answering my questions and giving me important insights.

Workshop guys I couldn't do anything without - Alan, Joe, Susanne and Chris!

Ian Watson for guiding my technical report and of course Nick for guiding my everything :)

Glossary

Entomophagy - the human use of insects as food.

Invertebrates - Familiar examples of invertebrates include insects; crabs, lobsters

Moulting - In many invertebrates the manner in which an animal routinely casts off a part of its body, either at specific times of the year, or at specific points in its life cycle.

Pinhead - newborn cricket

Nymph - a nymph is the immature form of some invertebrates, particularly insects, which undergoes gradual metamorphosis before reaching its adult stage.

Algae - term for a large, diverse group of photosynthetic organisms

Spirulina - a biomass of cyanobacteria (blue-green algae) rich in protein that can be consumed by humans and other animals.

Feed conversion (kg dry feed/kg live weight) - or feed conversion rate is a ratio or rate measuring of the efficiency with which the bodies of livestock convert animal feed into the desired output

Ovipositor - a long, needle-like or sabre-like egg-laying organ of the female cricket.

Gear ratio - is defined as the input speed relative to the output speed

Project Launch

For week 1 of our final year we had to have 3 ideas for final year project. We've been preparing for this moment throughout the whole degree. Especially the summer after 4th year. It's been the main topic of conversation prior to the year and all of a sudden no one knows what they want to do... very few people have ideas they feel excited about. It is an interesting phenomenon for sure.

So how did it all go for me?



Idea 1 - Meditation Device



Idea 2 - Mechanical teapot



Idea 3 - Future of food

Idea 1

Idea 1 was based on a project I did last semester in Norway. It was the biggest one for the year and a pretty similar situation - I had to come up with the thing I want to be designing myself. I wanted to use smart new technology to help people in meditative practices. Based on a lot of science papers I developed the idea of a hand-held device with various interaction paths - gathers a lot of biofeedback from the user, while it offers sound, haptics, light feedback to them.

It was quite a successful project - I developed a lot of prototypes and gathered positive responses from important people. It made sense not to leave it behind.

I wanted a new twist to it for this year though, instead of being something like an exercise tool, I wanted to target it to a specific use - fighting everyday addictions, and rendering the device as kind of a 'buddy' to these people, something that will provide the best support tailored to the user needs.

PRODUCT AIDING MINDFULNESS / MEDITATION PRACTICES USING SMART TECHNOLOGY
TO HELP PEOPLE OVERCOME EVERYDAY ADDICTIONS AND ESTABLISH HEALTHIER HABITS

Your perfect peace of comfort exactly when and how you need it.

"All of man's miseries derive from his inability to sit quietly in a room alone."
Pascal

Meditation's popularity in the Western world is exponentially growing due to its scientifically benefits for immense improvements in people's lives. One of its greatest lessons is learning to open up to discomfort instead of turning away from it or trying to stop it. This helps avoiding self-destructive, automatic responses to certain kinds of discomfort, such as the tendency to open the fridge when you're bored, drinking too many drinks when you're stressed or binge watching TV. There are many apps to help adopt mindfulness meditation techniques or stress managing devices on the market, but none that teaches you to be mindful while providing proper feedback and most importantly ready to save you at the very crucial moment of dysphoria, when the brain is seeking the known fast-reward.

Gergana Tatarova MEng PDE 5



THERE ARE PRODUCTS - THERE IS A MARKET



The market is full of meditation aiding applications, I just want to take it a step further. And it's funny how the more scientifically based one are lacking aesthetics.

Thync works by signaling nerves on the head and neck to act on the brain's adrenaline system. These nerves then activate your body's natural state of energy or calm. Comment: This is pretty cool but a bit scary - letting a machine bugs with your brain. I would try it. However I'm want something less intrusive.



Spire is a small device that you clip on your belt or bra, and it detects your inhalations and exhalations. This data gets sent to your iOS device, which provides insights into how you breathe. Spire also offers guided breathing exercises and meditations, called Boosts. You can download these and listen to them to calm down, enhance focus, and more. Comment: Spire lacks interactive element. Breathing measurement is not accurate enough to give mental state information.



Gergana Tatarova MEng PDE 5

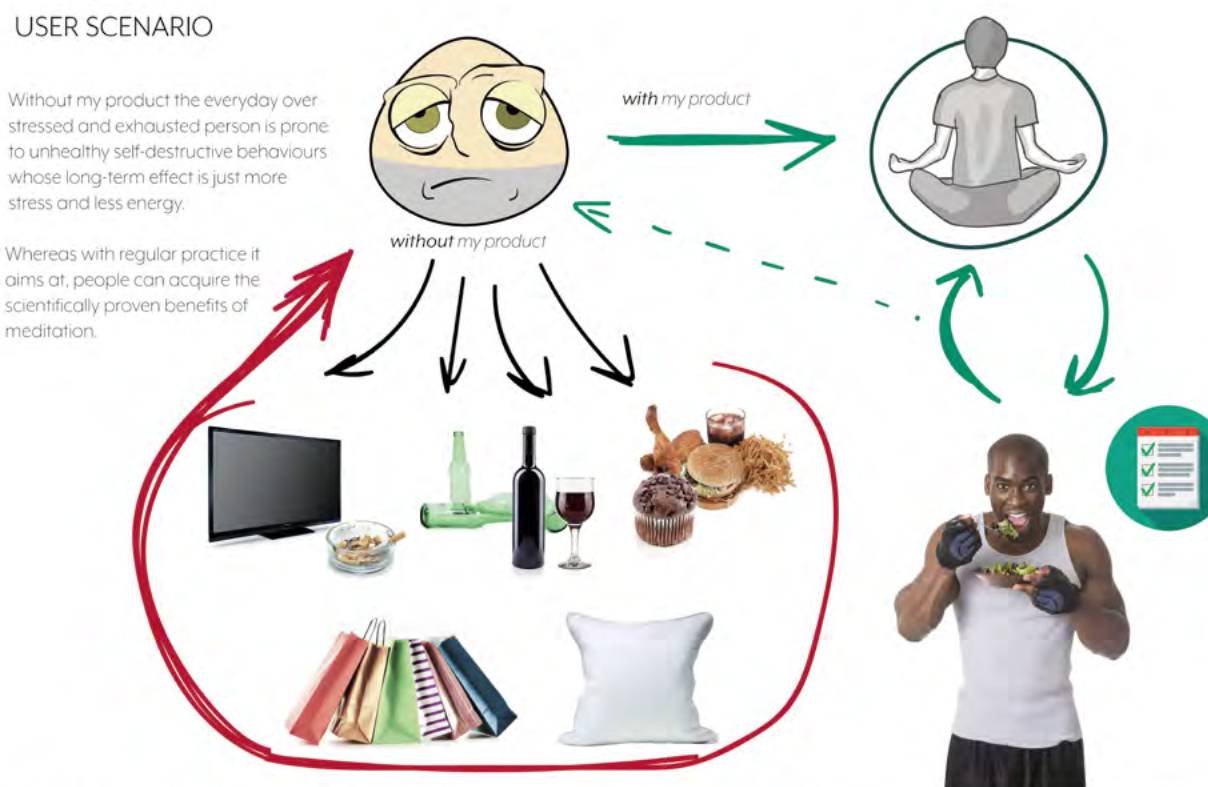


Muse is your personal meditation assistant. Sometimes your mind is calm and sometimes it's active. Muse will guide you to a calm mind. When you're calm, you'll hear peaceful weather sounds. When your mind wanders, the weather will intensify, guiding you back to a calm state. It uses EEG sensors. Comment: It is cool. I like that it sounds easy to use. Again, I want my device to be usable all the time without looking like RoboCop.

USER SCENARIO

Without my product the everyday over stressed and exhausted person is prone to unhealthy self-destructive behaviours whose long-term effect is just more stress and less energy.

Whereas with regular practice it aims at, people can acquire the scientifically proven benefits of meditation.



Boosts happiness, Increases productivity, Boosts health, Boosts self-control, Improves brain

Gergana Tatarova MEng PDE 5

Idea 2 was provoked by my weird tea drinking habits that I cannot find anything that caters for. I always make massive pots of tea using various teabags/blends/herbs and it ends up being too bitter, due to oversteeping, and cold. I wanted a mechanical solution to the problem - timer and spring mechanism to get the tea bags out for me. I got excited about it cause it seemed it could be a lot of fun prototyping, a lot of mechanisms and materials knowledge required and aesthetics challenges on the way.

I had almost decided on it, until someone told me about Sage by Heston Blumenthal and all my enthusiasm plummeted. I still wanted to make a fully mechanical teapot that you can use on the stove, not a kettle kind of thing. But technically I wasn't solving an unresolved problem.

SIMPLY FUNCTIONAL TEAPOT

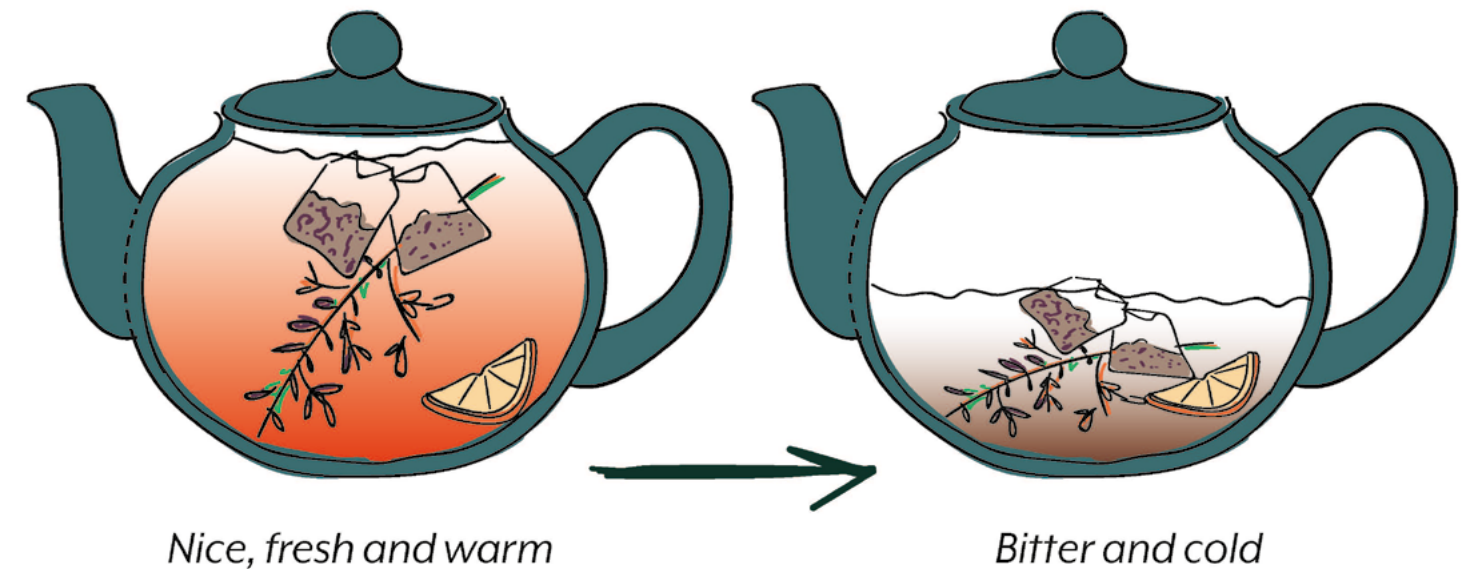
Your best friend during the long hours in front of the screen pretending you're working hard while clicking on the next cat video.

WHO:

Lone all-day-long tea drinker that doesn't have 200GBP to spare.
Hopefully the resulting product will be liked by many more.

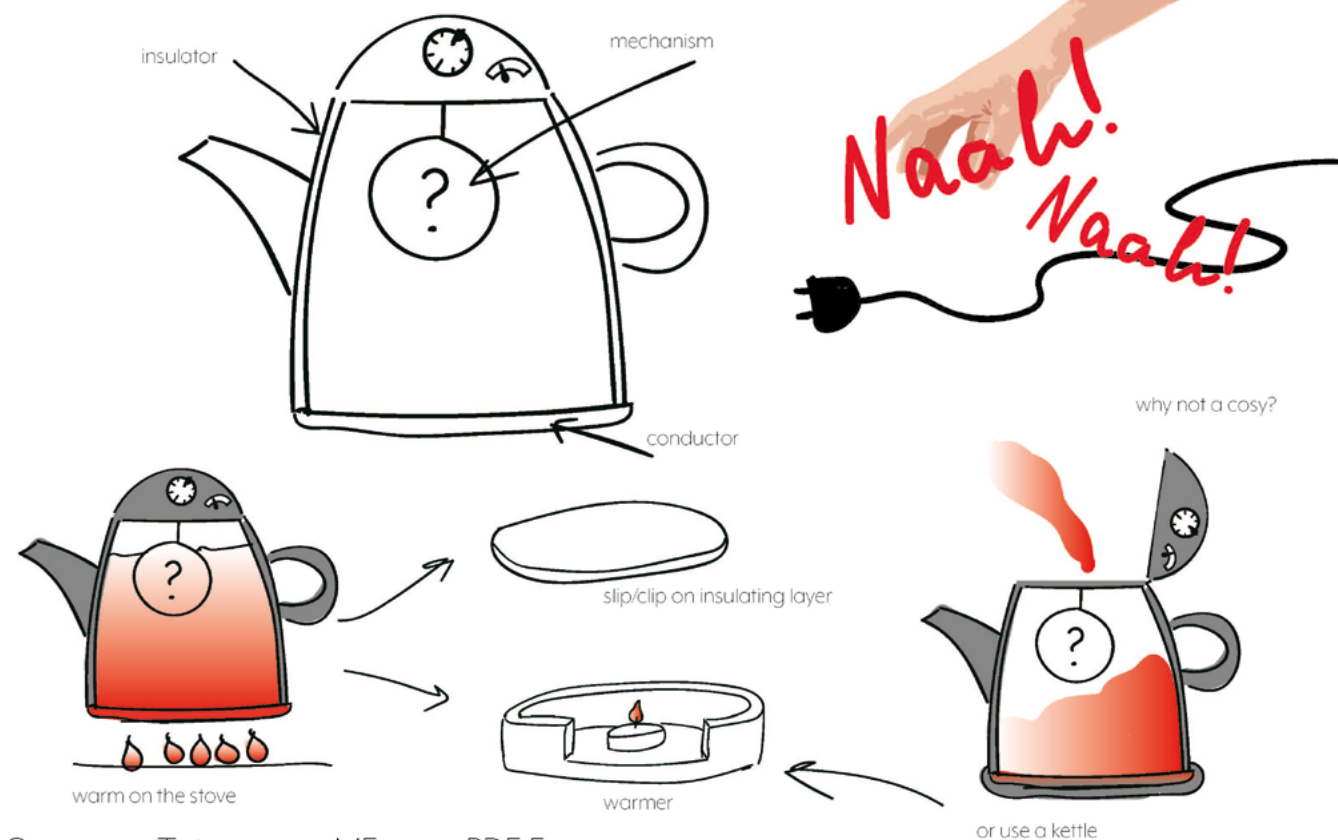
PROBLEM:

Perfect at the beginning, but too warm to get the tea bags out - results in a cold and bitter substance couple of hours later.



Gergana Tatarova MEng PDE 5

POSSIBLE SOLUTIONS



Gergana Tatarova MEng PDE 5

FOCUS BOARD

I lost my excitement when I discovered that the Sage product does exactly what I want mine to do. But then I decided that it would be still a nice design project to try and make it my way - purely mechanically, no electricity what-so-ever, with a cosy, less kitchen-appliancey feeling to it.



Gergana Tatarova MEng PDE 5

Idea 3

And again I think the situation was pretty similar for everyone, people had few more ideas they really didn't feel like doing, trying to come up with a new one to get their 3rd place coming up with even more, that still don't sound very exciting.

My final idea had few factors involved to form: 1 was that I love experimenting in the kitchen and one of my passions is to find novel ways to sneak in protein in seemingly carb foods i.e. I'm most proud of my Tuna pizza crust. I have heard about using cricket flour as an awesome flour substitute and wanted to buy some and was surprised how expensive it was! Then I heard that it wasn't that difficult to breed them and Entomophagy (eating insects) is becoming more and more popular in the Bay area with a lot of emerging start ups.

Starting to get excited about the idea of breeding and eating insect, there was one thing I completely forgot about until i googled 'Grubs' and after some pictures appeared I screamed and cried a bit and couldn't bring myself to look back at the computer to close the tab.

I dropped the idea for a couple of days trying to come up with something else, but then I remembered a 'Meet the meatball of the future' exhibition by a Scandinavian company called Space 10 that were exploring quite a few options (Insects, Algae and Microgreens were the ones that interested me the most, but they had also powder and garbage based ones). Reading more about food sustainability issues motivated me to peruse that area and taking the challenge to overcome my phobia of insects in the mean time.

the **FUTURE OF FOOD** at every home
Good nutrition - healthy people, smart nutrition - healthy planet!

A lot more people go vegetarian and vegan for environmental reasons. It is true that most of the farming nowadays is very damaging to our planet, and the way the animals are looked after makes them damaging to us the consumers, too!

But should we all try to get all of our protein from chickpeas and beans and far* ourselves to exhaustion while trying to get the amount of protein we need, just to prove that we care? Not really!

credit for awesome balls posters: Space 10

THE LEAN GREEN ALGAE BALL

Tomorrow's Meatball

There are far better ways to source good nutrition, we just need to educate ourselves and make the right tools.

Bringing Entomophagy (consumption of bugs as food) to the modern home is just one of the opportunities to get creative and be sustainable!

THE CRISPY BUG BALL

Tomorrow's Meatball

THE MIGHTY POWDER BALL

Tomorrow's Meatball

Feed your meaboom

Harvest your meaboom

Enjoy your protein!

Growing your own nutritional vegetables and proteins (bugs) becoming a norm at every home would be my dream solution, but it definitely won't be easy mainly due to familiarity and association people have. If the benefits are harvested and presented in a not bug-like form people would be more willing to adapt this up to 20 times more efficient way of getting food than traditional livestock.

G Tatarova MEng PDE 5

Evaluation against given criteria



Choice - Idea 3

Long story short, I decided to investigate future food solutions for everyone's home concentrating on normalising bug eating in the Western countries.

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I am not sure I managed to arrange this chapter very well. What it is trying to convey is that I did deep dive into the problem and opportunity, into the context, thorough user and cricket testing to come up with product requirements.

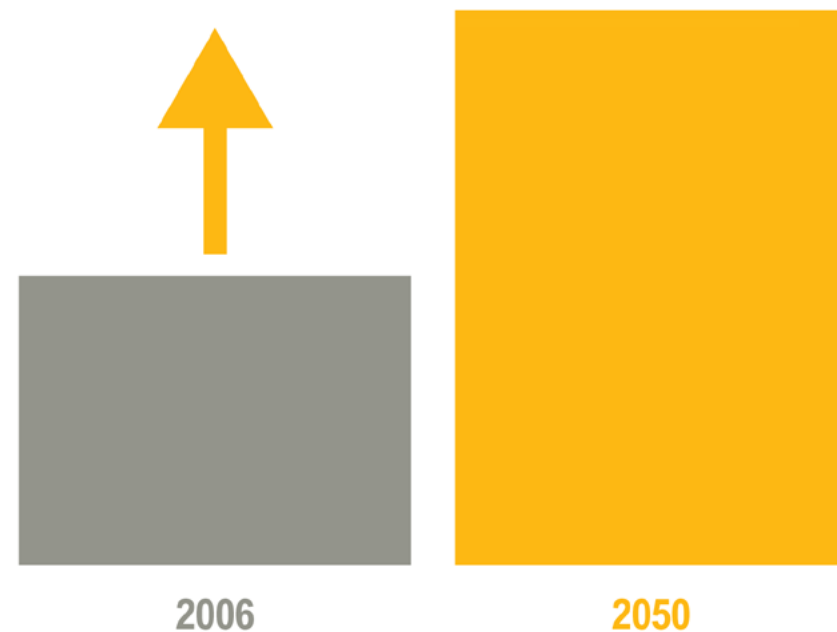
Food problem in numbers

The world population at the moment stands at 7.3 billion. Predictions suggest the number will rise to 8.5 billion by 2030, 9.7 billion by 2050 and 11.2 billion by 2100. This means doubling the meat consumption in the next 30 years. Current methods of meeting the food demand are simply unsustainable and have a vastly negative impact on the environment.

18% of the Greenhouse gas (GHG) global human induced emissions are from livestock production. The number includes transport of livestock and feed.

The World Needs to Close a 70% Food Gap

70% **REQUIRED INCREASE** in food calories to feed **9.7 billion** people by 2050



wri.org/shiftingdiets

 WORLD RESOURCES INSTITUTE



Special thanks to John for recommending me this book! It makes a really strong and educated statement about the not-so-good situation we're in.

Each year, around 70 million people are added to the world's population. If growth continues at this rate, by 2050 the population is expected to reach a 9 billion.

To feed all of those hungry mouths, we will need to produce almost twice as much food as we currently do. But we already use 70% of agricultural land to raise livestock

Alternatives are needed!

Could insects solve it?

Insects are cold-blooded and thus require less energy to maintain their internal body temperature.

Entomophagy - (/ˌɛntəˈmɒfədʒi/, from Greek ἔντομον éntomon, "insect", and φάγειν phagein, "to eat") is the human use of insects as food.

It takes 10kg to produce 1kg of beef, only half of which can actually be eaten. On the other hand 10kg of feed will produce 9kg of insects of which over 95% can be eaten!

Crickets only produce 2g of CO₂ per 1kg, that is extremely low compared to cattle, which produce 2850g of CO₂!

Turns out it takes a whopping 90 percent less land to produce mealworms than it does to produce beef and 43 percent less land than it takes to produce milk.

around 1,900 species of insects have been identified as suitable food for humans

Caterpillars contain 280g of protein per 1 kg. That's 20g more than salmon, 30g more than pork, and 263g more than tofu.

1 kg of termites provides, roughly, 350g of protein, whereas the same amount of beef contains 320g.

Why should I eat insects?

With claims of incredible nutritional value, low environmental impact and delicious 'new' flavours, edible insects have had a lot of hype recently. What's the truth behind the headlines? And why is an ingredient eaten by two billion worldwide so 'new' in the west?



Can Eating Insects Save the World BBC full Documentary 2013 (Insect eating animals)



Produced by **Rosforth** and **Danish Documentary**, the film has an inquisitive approach as the team encounters and documents the contradictions and controversies around entomophagy. We also join Nordic Food Lab in their experiments with culinary practices and taste – in a two-way process of learning from others around the world while trying to push boundaries themselves.

Nutrition

Approximate nutritional values per 100 grams freeze-dried product:

Buffalo Worms:

Energy (kcal/100g) 484
Fat (g/100g product) 24.7 of which
Saturated fatty acids 8.0
Mono-unsaturated fatty acids 9.5
Poly-unsaturated fatty acids 7.0
Carbohydrates (g/100g product) 6.7 of which
Sugars (g/100g product) 0
Fibre (g/100g product) 5.2
Protein (g/100g product) 56.2
Salt (g/100g product) 0.38

Mealworms:

Energy (kcal/100g) 550
Fat (g/100g product) 37.2
Saturated fatty acids 9.0
Mono-unsaturated fatty acids 17.3
Poly-unsaturated fatty acids 10.9
Carbohydrates (g/100g product) 5.4 of which
Sugars (g/100g product) 0
Fibre (g/100g product) 6.5
Protein (g/100g product) 45.1
Salt (g/100g product) 0.37

Crickets:

Energy (kcal/100g) 458
Fat (g/100g product) 18.5 of which
Saturated fatty acids 7.0
Mono-unsaturated fatty acids 5.3
Poly-unsaturated fatty acids 6.4
Carbohydrates (g/100g product) 0 of which
Sugars (g/100g product) 0
Fibre (g/100g product) 7.7
Protein (g/100g product) 69.1
Salt (g/100g product) 1.03

Locusts:

Energy (kcal/100g) 559
Fat (g/100g product) 38.1 of which
Saturated fatty acids 13.1
Mono-unsaturated fatty acids 13.0
Poly-unsaturated fatty acids 11.9
Carbohydrates (g/100g product) 1.1 of which
Sugars (g/100g product) 0
Fibre (g/100g product) 8.4
Protein (g/100g product) 48.2
Salt (g/100g product) 0.43

All data gotten from Crunchy Critters - the main UK supplier for edible insects. All of them are imported from Asia.



From the Editor

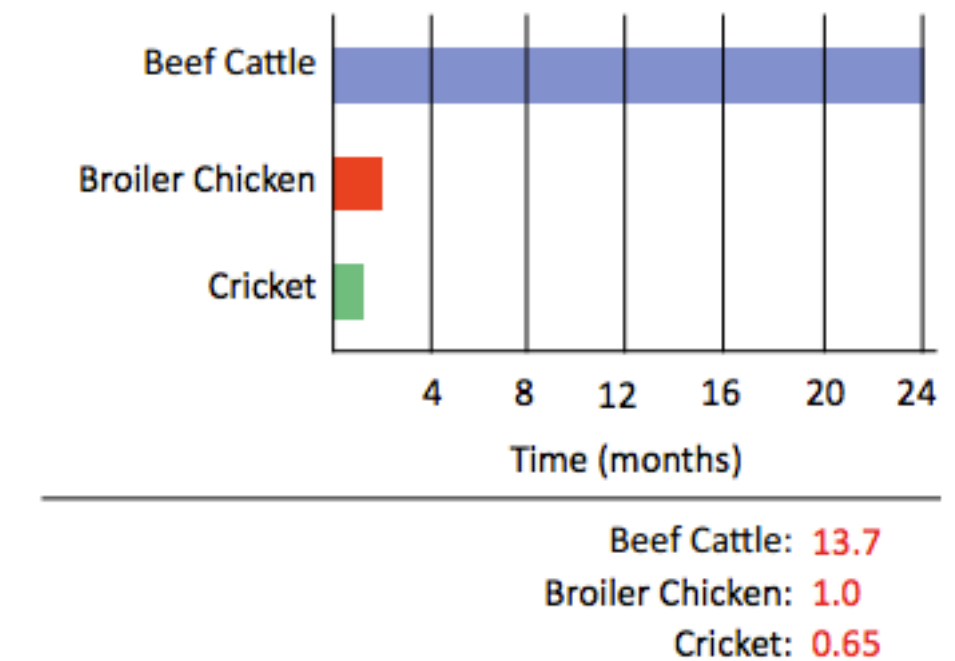
Insects as a source of nutrients: Beyond the Western prejudices

Christiane L. Girard

Dairy and Swine Research and Development Centre, Agriculture and Agri-Food Canada, Sherbrooke, Québec, J1M 0C8, Canada

Review article
Section: Food Quality and Functionality

Maturation Age



A Comprehensive Look at the Possibilities of Edible Insects as Food in Europe – a Review

Jiri Mlcek^{1*}, Otakar Rop^{2†}, Marie Borkovcova³, Martina Bednarova⁴

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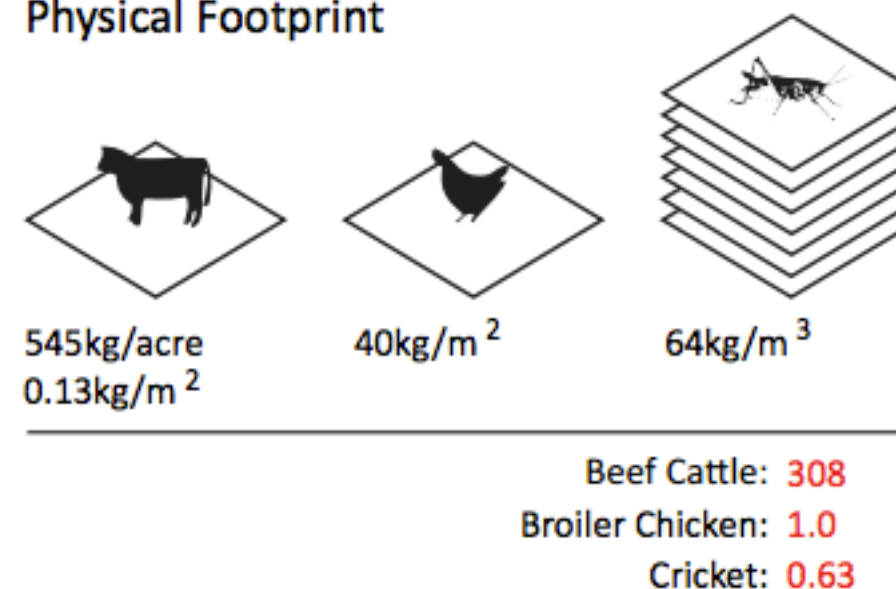
INSECTS AS FOOD: Why the Western Attitude Is Important

Gene R. DeFoliart

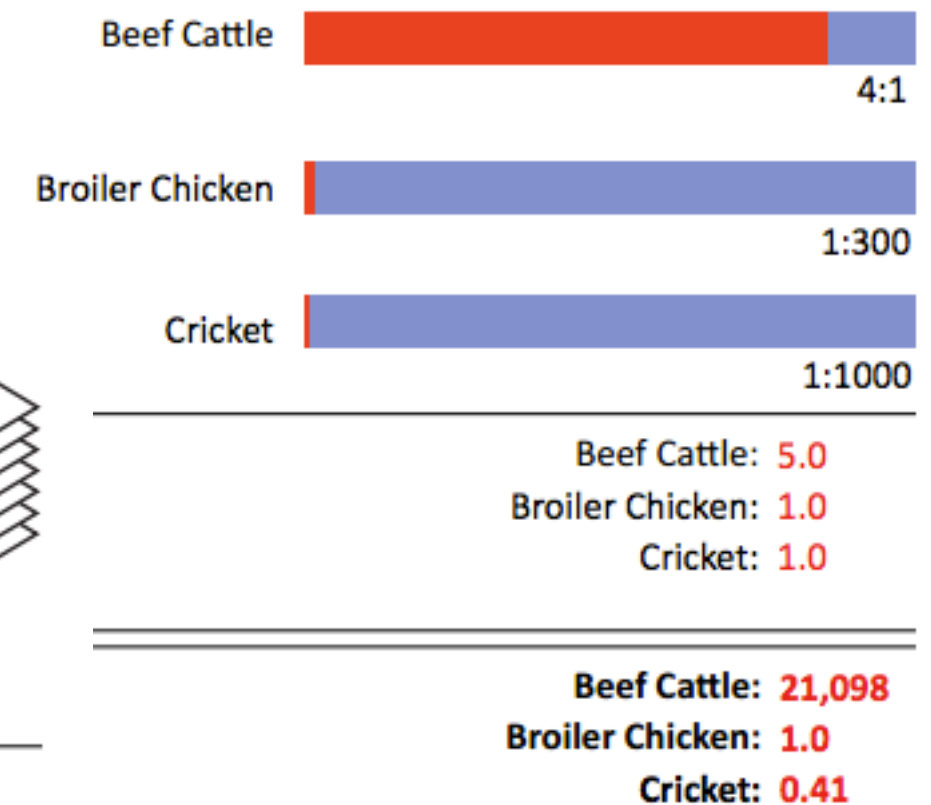
Department of Entomology, 545 Russell Laboratories, 16 Linden Drive,
University of Wisconsin, Madison, Wisconsin 53706

KEY WORDS: edible insects, entomophagy, food ecology, food insects, minilive
nutrition

Physical Footprint



Breeding Base (ratio of breeders to population)



ENVIRONMENTAL Benefits of Crickets

HERE'S HOW INSECT CONSUMPTION BENEFITS THE ENVIRONMENT

FEED

Crickets require less feed than animal protein sources.

FEED REQUIREMENTS PER KILOGRAM OF

	Beef: 10,000 grams	
	Pork: 5,000 grams	
	Chicken: 2,500 grams	
	Crickets: 1,700 grams	

WATER

Crickets require far less water than animals and can be grown throughout a drought.

WATER REQUIREMENTS PER KILOGRAM OF

	Beef: 2,500 gallons	
	Pork: 800 gallons	
	Chicken: 567 gallons	
	Crickets: 1 gallon	

GREENHOUSE GASES

Crickets produce significantly fewer greenhouse gas emissions than animal protein sources.

The only insects that produce methane as a waste product are cockroaches, termites, and scarab beetles.

GREENHOUSE GAS PRODUCTION PER KILOGRAM OF

	Beef: 2,850 grams	
	Pork: 1,130 grams	
	Chicken: 300 grams	
	Crickets: 1 gram	

ANIMAL WELFARE

Crickets don't mind living in highly dense populations.

They're often frozen, which puts them in a dormant state called diapause. Then they are placed in a deeper freeze, which kills them humanely.

SPACE REQUIREMENTS PER KILOGRAM OF

	Beef: 200 square meters	
	Pork: 50 square meters	
	Chicken: 45 square meters	
	Crickets: 15 square meters	

DISEASE

When compared to poultry, cattle, and pork, crickets have a much lower risk of passing on diseases to humans.



Similar projects

LIVIN Farms Hive



This Modular Cricket Pod Lets You Create An Urban Insect Farm

The Cricket Shelter is designed to grow delicious crickets that are both free-range and local—just like we expect for the rest of our food.



<https://www.fastcompany.com/3059181/this-modular-cricket-pod-lets-you-create-an-urban-insect-farm>

There is Interest, There is Hype!



New kit to get you eating insects



Courtney Yule wants to get you eating insects.

Published: 12:39 Wednesday 13 May 2015



Chocolate insect fondue, anyone?

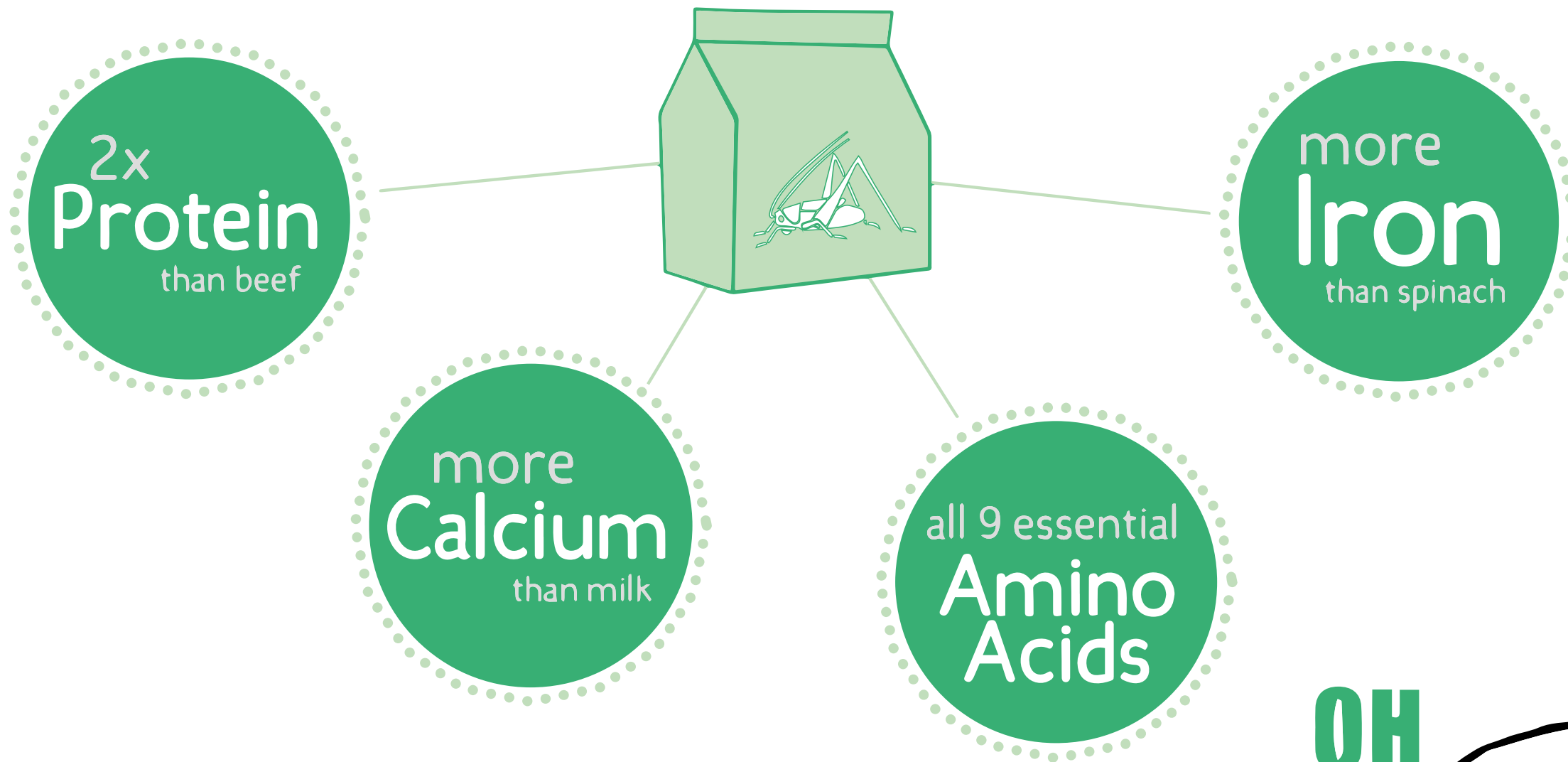
Courtney Yule

Describe project and say that i'd contacted her

<http://courtneyyule.co.uk/Product-Graphics/ENTOPOD>

<https://www.youtube.com/watch?v=BqKU6v3HUAU>

<http://www.edinburghnews.scotsman.com/news/new-kit-to-get-you-eating-insects-1-3771609>

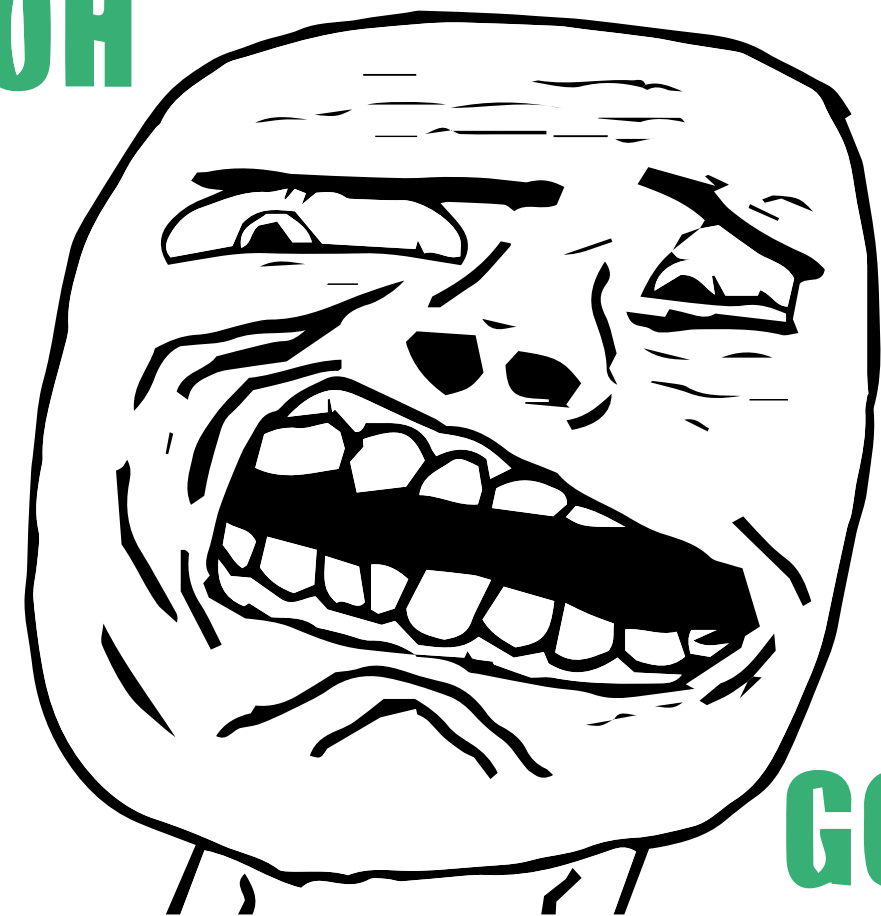


Summary

Eating insects is good. Good for us. Good for the planet. Why don't we eat them here yet? Let's find out.

Also - crickets forward due to not being worms and having relatively straightforward life-cycle.

OH



GOD

Opportunity, Market, Context



WHO EATS BUGS?

COUNTLESS CULTURES AROUND THE WORLD EAT INSECTS AS A DELICACY OR AS A NORMAL PART OF THEIR EVERYDAY DIET. UP TO 80% OF THE WORLD'S NATIONS EAT INSECTS WITH HIGHER CONCENTRATIONS LOCATED IN THE TROPICS



RESEARCH PROVIDED BY: FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. EDIBLE INSECTS: FUTURE PROSPECTS FOR FOOD AND FEED SECURITY. INFOGRAPHIC BY JUSTINKYLE.NET FOR LITTLE HERDS.ORG

Potential of Insects as Food and Feed in Assuring Food Security

Arnold van Huis

Laboratory of Entomology, Wageningen University, Wageningen 6700 EH, The Netherlands;
email: arnold.vanhuis@wur.nl

A lot of the studies on the topic concentrate on the benefits of eating insects. Not so many go into depth with what the issues around it are. Arnold van Huis paper goes a bit beyond.

NEED FOR ALTERNATIVE PROTEIN SOURCES
BENEFITS OF MINI-LIVESTOCK COMPARED TO LIVESTOCK
Greenhouse Gas and Ammonia Emissions

CONSUMER ACCEPTANCE

Knowledge about consumer preferences and barriers for using insects as human food and animal feed is scanty but necessary in order to set up commercialization trajectories. In aquaculture and aviculture, the inclusion of insects in feed will probably not be considered a problem by consumers, as insects are already natural feed for fish and birds.

Concerning insects for human consumption, (whole) insects are an accepted food item in most culinary cultures of the world, although there are taboos (81). Food acceptance is controlled by affective, personal, cultural, and situational factors, but motives are based mostly on sensory/pleasure considerations and health. Humans are inclined to avoid unfamiliar foods (neophobia), particularly when they are of animal origin (89). With these novel foods, humans exhibit both an interest in (obtaining a wide variety of nutrients) and a reluctance to (the possibility that these foods may be harmful or toxic) eating them (the omnivore's dilemma). Neophobic reactions toward novel foods of animal origin may be decreased by lowering individuals' perceptions of their disgusting properties (89). Initial disgust with respect to a certain food can be turned into a preference, e.g., sushi in the Western world. Such an example shows that food preferences are not stable and can change over time. Considering that consumer acceptance of insect food and food ingredients is a significant barrier, broad public debate can explain the sustainability of food production systems and the need to find alternative protein sources that are acceptable. Appropriate processing strategies could be

developed. This is a challenge for industries specialized in the mass rearing of insects for biocontrol, sterile insect technique, and pet feed (18). The major issues in mass rearing are quality, reliability, and cost-effectiveness. In addition, pathogens such as the *A. domesticus* densovirus can constitute

Spirulina!!!!

Challenges in cricket farming

<http://teca.fao.org/read/7927>

High cost of high protein feed: approximately half of the production cost is feed, which is commercially produced by the chicken industry. Therefore, cricket farming is vulnerable to price increases in the chicken feed industry, which undermines profitability. Research is needed to find low cost or free protein sources to develop into a special feed formula for crickets.

Disease: currently, disease risk is almost non-existent. However, in the future, with continuing high density cricket populations, disease problems are likely to arise. There have been a few cases of crickets dying without any disease symptoms or pathogens. It is suspected that overcrowding or contamination by fungi in the feed may have been the cause.

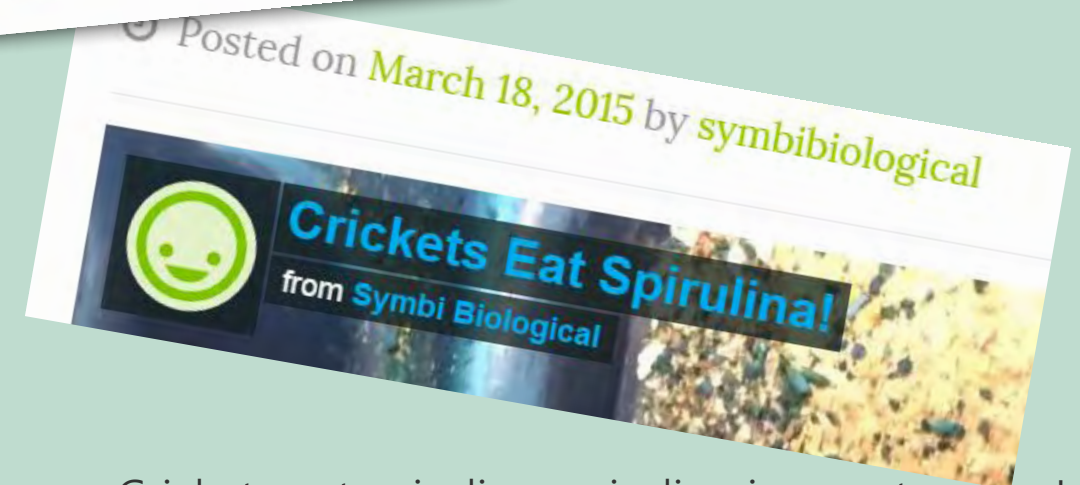
In-breeding: is another risk as many cricket farms are closed units using breeding stock produced on the farm. Already on some cricket farms the effects of in-breeding are visible with less active and slow-maturing crickets. The problem seems to arise after three generations, so sourcing breeding stock and eggs outside the farm should be a recognized best practice for all farmers.

Crickets Are Not a Free Lunch, Protein Conversion Rates May Be Overestimated

April 15, 2015 by [Entomology Today](#) 6 Comments



more popular in america, cannot find it.



Crickets eat spirulina, spirulina is easy to grow!

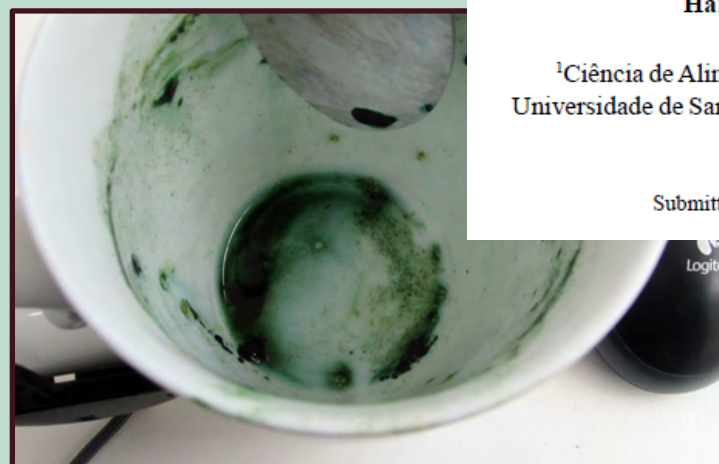
Algae for the win - message Ian Waston

CULTIVATION OF *ARTHROSPIRA* (*SPIRULINA*) *PLATENSIS* IN DESALINATOR WASTEWATER AND SALINATED SYNTHETIC MEDIUM: PROTEIN CONTENT AND AMINO-ACID PROFILE

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Submitted: December 20, 2006; Returned to authors for corrections: May 31, 2007; Approved: January 14, 2008.

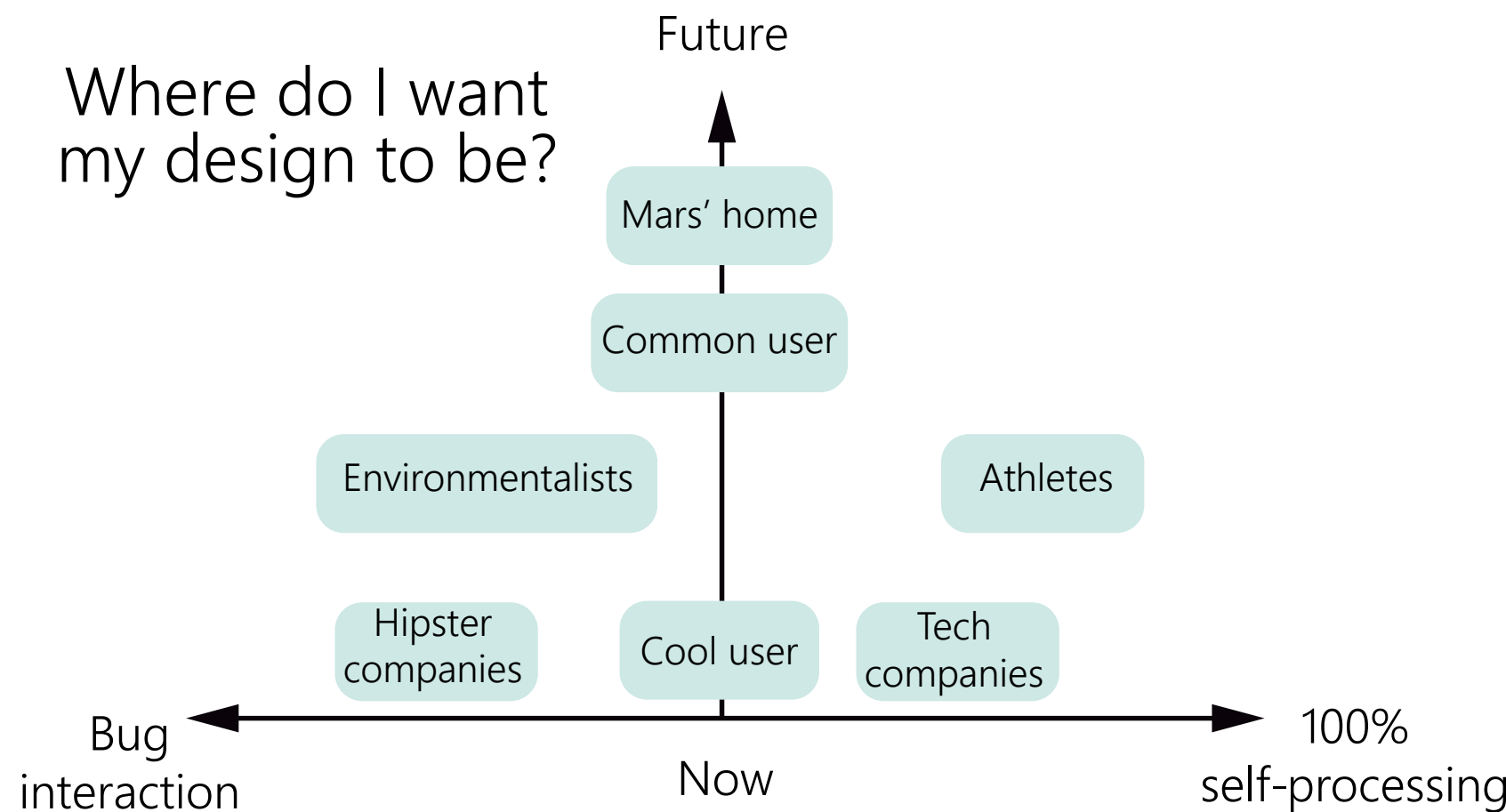
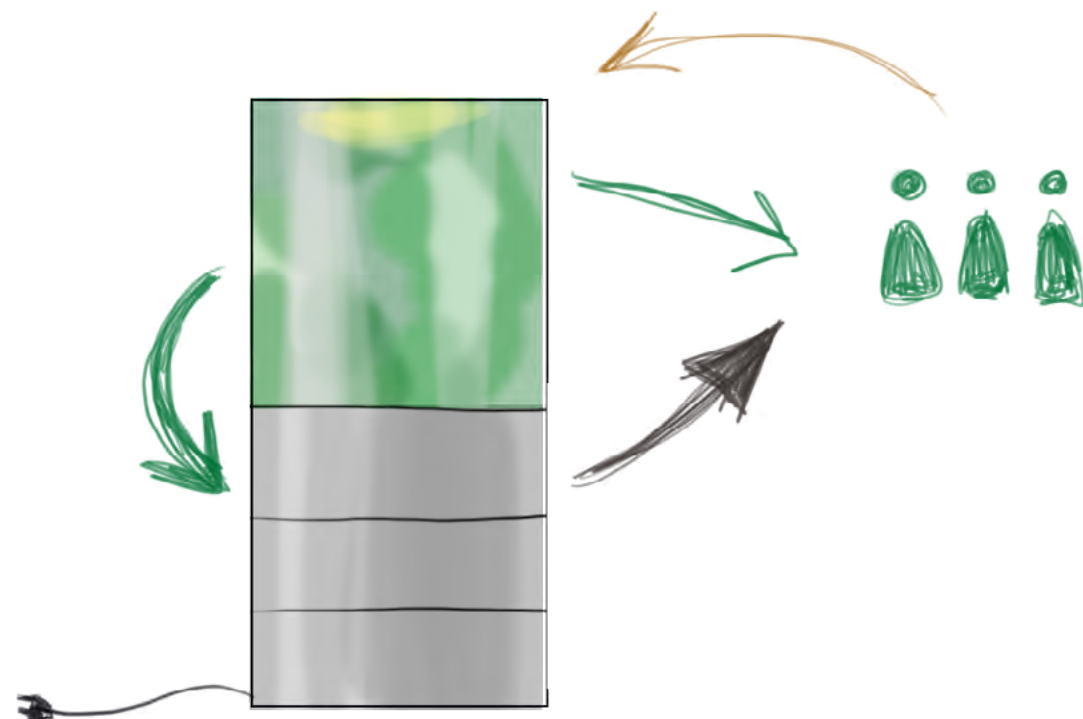


Product rough idea

I rough idea started to continuously appear. Algae feeding crickets, both feeding humans and potentially using human urine to feed the algae.

I needed much more human research to decide who is my product for?

Should it farm crickets and dispense them for cooking? Or cricket flour? Or cricket power bar?



Initial concept interaction





People feel generally better towards eating insects made foods where you cannot actually see the insect itself.

Why are they scared of the whole bug?

I am going to hit pause here and tell you about my phobia and overcoming it.



HAV CP



Phobia overcoming

I want to go deeper in the project but still cannot due to inability to look at pictures of bugs

I am still trying to contact someone from psychology department at Glasgow uni, but to no avail. I want to talk about Animal and Insect phobia threatment and potentially get step-by-step guide on how Systematic Exposure could be best applied.

the internet suggest to

-Make a list of the frightening situations related to your phobia.

-Build your fear ladder. Arrange the items on your list from the least scary to the most scary. The first step should make you slightly anxious, but not so frightened that you're too intimidated to try it. When creating the ladder, it can be helpful to think about your end goal

-Work your way up the ladder.

-Practice. It's important to practice regularly. The more often you practice, the quicker your progress will be. However, don't rush. Go at a pace that you can manage without feeling overwhelmed.

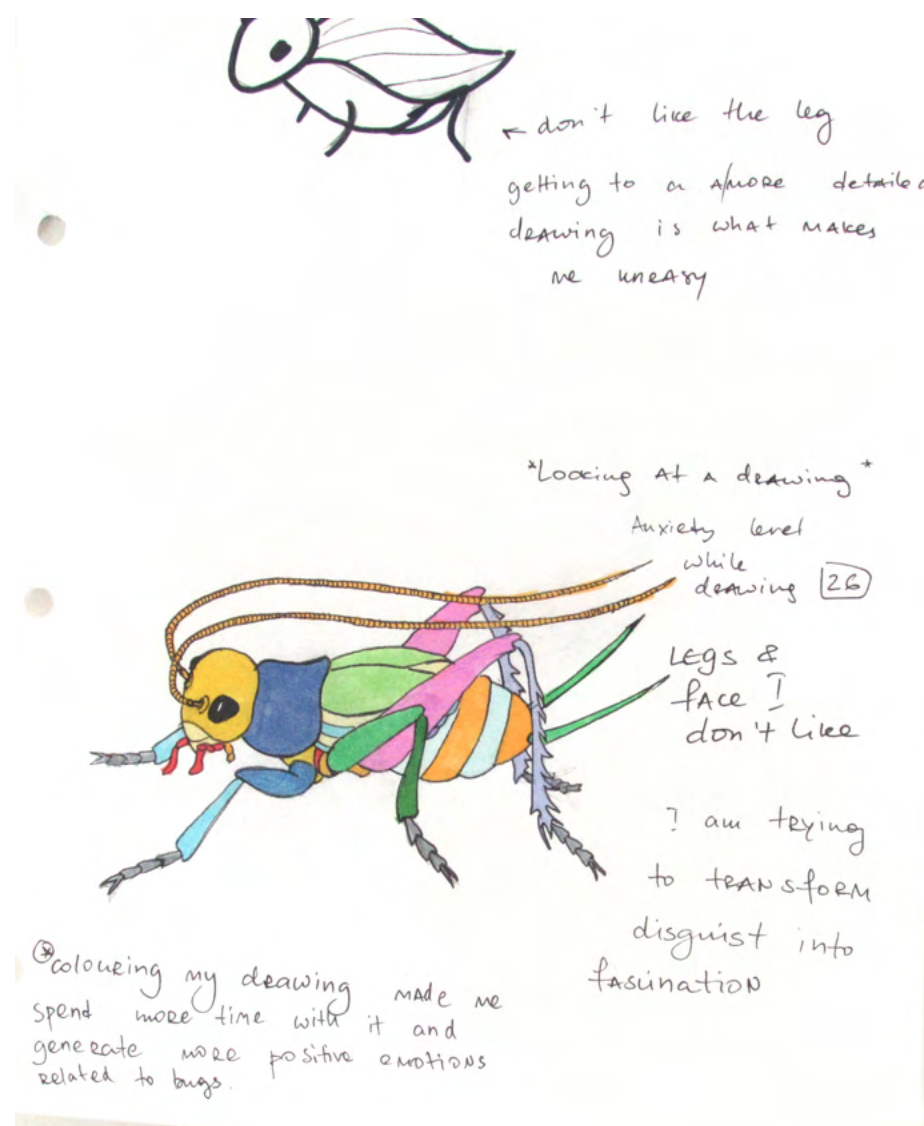
I believe evaluation is really important though so I need to put some fear / anxiety / disgust factor and see how it changes. 1-100.

Fear ladder:	Anxiety/Disguist/ Fear 1-100 evaluation at the start
Thinking about a nasty bug.	9
Thinking about someone else eating a nasty bug	12
Imagining myself eating a bug	20
Looking at a drawing of a nasty bug	30
Looking at distanced picture of a nasty bug.	40
Looking at a close up of a nasty bug.	60
Picture of someone eating a nasty bug.	70
Seeing a nasty bug from a distance in real life	75
Seeing it from close up, if it moves unexpectedly +30	90
Holding a living nasty bug	100
Eating a dead one	100



<https://ingenueexplores.wordpress.com/2017/01/07/entomophagy-eating-insects-overcoming-phobia-while-saving-the-world-almost-d/>

Exposure therapy (desensitisation) involves gradually increasing the length of time you're exposed to your phobia.



I had a really really bad phobia. And a lot of stories involving insects, crying and screaming.

Partially reading about exposure therapy, partially making up my own route I started brainstorming different ways I could design my way out of the phobia.

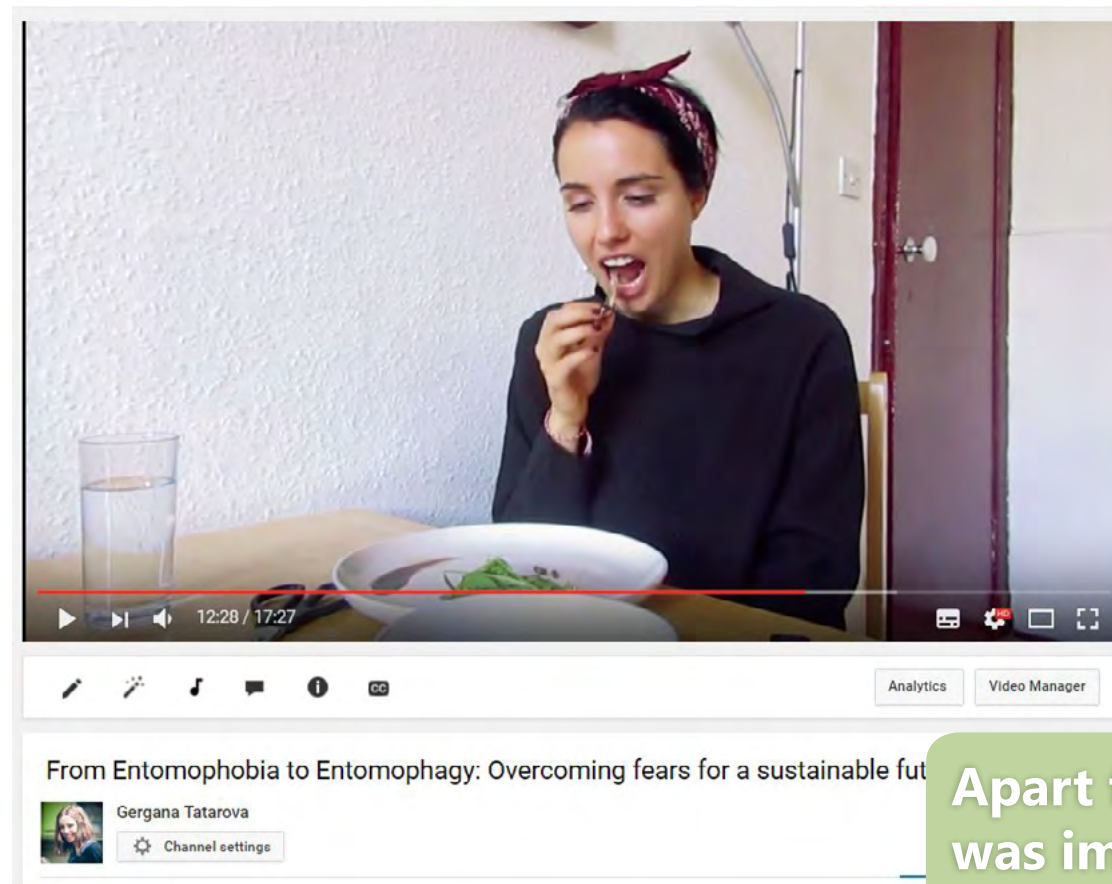
I came up with redrawing drawings at first. From very simplistic to a bit more complex ones. I had a bit of troubles even with the first one, mainly worrying about getting to the next though.

I was quite happy with my progress cause by the end of the day I could watch videos with actual crickets meter away from the screen and with only just one eye closed.



I was excited to receive the package. Mentally ready to open it and see the cover I got used to... but it turned out I opened it facing the transparent face (which I did not expect) which resulted in throwing it in the year while screaming and then 10 minutes uncontrollable sobbing.. mentioning few times "maybe I cannot do this project.. Maybe I overestimated myself.."



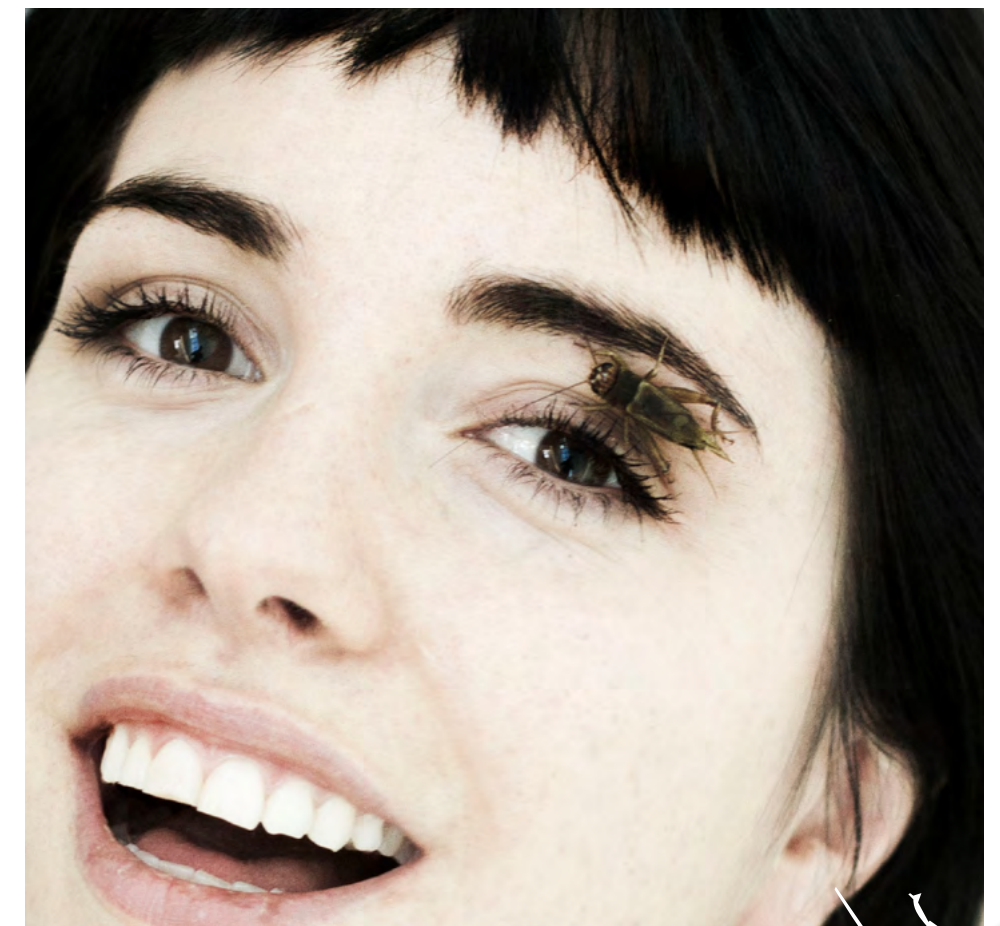


After a bit of unsuccess with trying to eat some and getting panic attacks and being close to changing my whole project, the exposure contnued with some more drawings, then eating some insects, starting breeding my own.

I wouldn't say it was easy, but definitely worth it.

Putting a bug on my face felt like a win.

Apart from it being a personal challenge it was important to know that even a severe fear should not be a problem when it comes to introducing insects to our diet.



Field Research and user testing

1st visit to Patisserie Maxime

Following my overcoming of my fear video that I posted on facebook, all of my friends knew about my project and interest in Entomophagy.

Patisserie Maxime in Edinburgh has recently introduced insects, flour and whole ones, to some of their cakes, originally because of Halloween approaching, but due to the hype they will probably keep up with that menu.

As soon as I heard, few friends told me immediately. also Aileen e-mailed, I booked my tickets to pay them a visit.

I wanted to spend few hours there, observing the customers, talking to the staff about people's reaction, who buys the cakes with flour inside but no visible bugs and who gets the ones with worms on top.

I wanted to talk with the chefs about incorporating the flour into their recipes, was it easy or challenging, are they thinking of making more and more cakes with insects?

The staff suggested I arrange a meeting with the owner to get all the answers I need.

After spending an awesome day in Edinburgh I wouldn't mind at all going again :)





The visit in pictures.



We went there in the afternoon and the most popular worm brownies had sold out.

As expected after the BBC coverage of the place, it has become much more popular and people were coming just to try the insect cakes. It was thanks to the hype that I got here too.

I had a Chapuline Lemon Tart with both flour from Chapulines (type of Grasshoppers) and whole bugs too. It was good! .. but too sweet for my taste. I will try to bake some healthier cricket flour products with the flour I got.

As you can see, there was also STV there having a live coverage of the cafe. I spoke to the guys about their visit and they were quite interested in my project and told me to contact them when I'm few months in and have something to show!

So an awesome day in Edinburgh and I will be going back to speak to the owner and get all the golden nuggets out!



In the mean time I really needed to understand who the user is and what should the value be of my product. I needed to understand people's opinions better!



User group characteristics

A Norwegian friend's friend explaining why and how he's breeding mealworms.



Alexander Jonassen

01/10/2016 12:07

Yeah, I've started breeding mealworms. I watched a TV-series from NRK called "Live Nelvik saves the world. A bit." In one of the episodes, they made mealworm taco.



Alexander Jonassen

01/10/2016 12:09

I've been open for eating insects a long time, so this kinda the final push. That, and a friend of mine who also watched the episode said we just had to try this worm taco sometime. And when he said sometime, I knew I would have to take the initiative, or else it would just fade away.



Alexander Jonassen

01/10/2016 12:10

But there is no place to buy quantities of mealworms in Norway yet, so I went to a pet store and bought 50 worms for 50 NOK. It would be way to expensive to buy worms for an entire taco meal, so I figured I'd breed them myself.



Alexander Jonassen

01/10/2016 12:15

But this is a slow process, and I suspect I'll breed until I have enough for a taco meal, but after that I'll stop. It's an experiment. And my main motivation? Curiosity, preparing for the food of the future, and reducing meat consumption.



Personas



Tim

Student
Curious
Travels



Kimberly

Fitness
Accountant
Nutrition - protein



Casper

Cooks a lot, experiments
Young entrepreneur
Brews beer hobby
Gluten sugar free
paleo



Zara

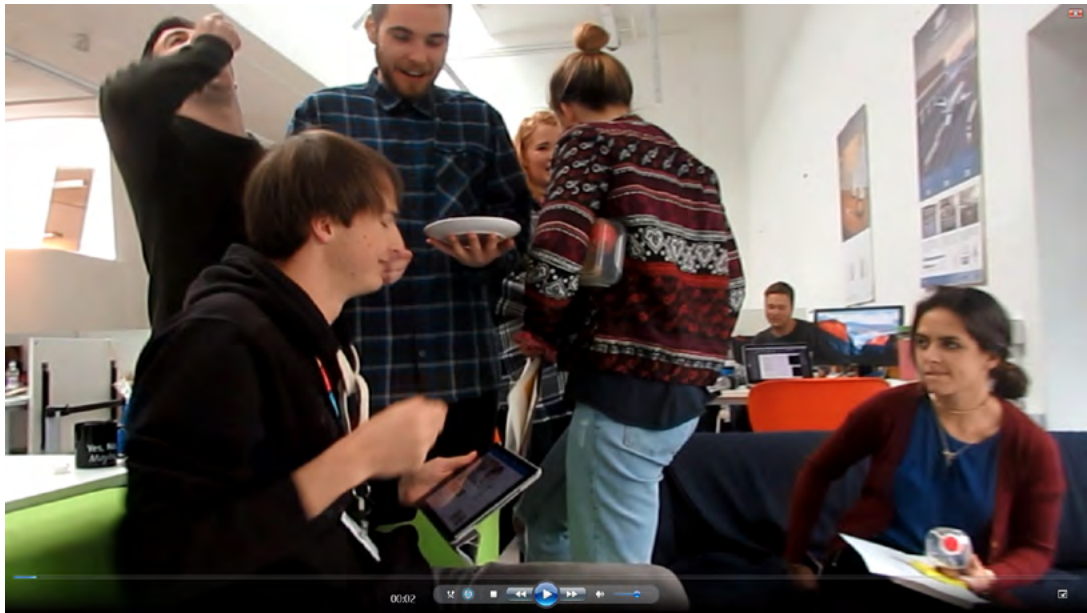
student
environmental activist
open to future of food
no time for cooking

environment, money, protein

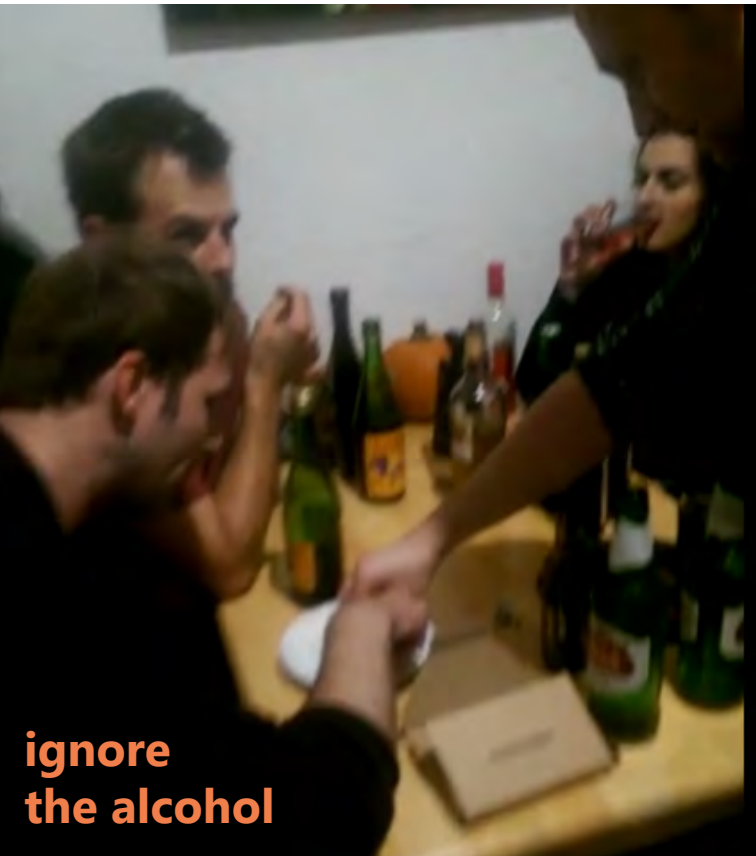
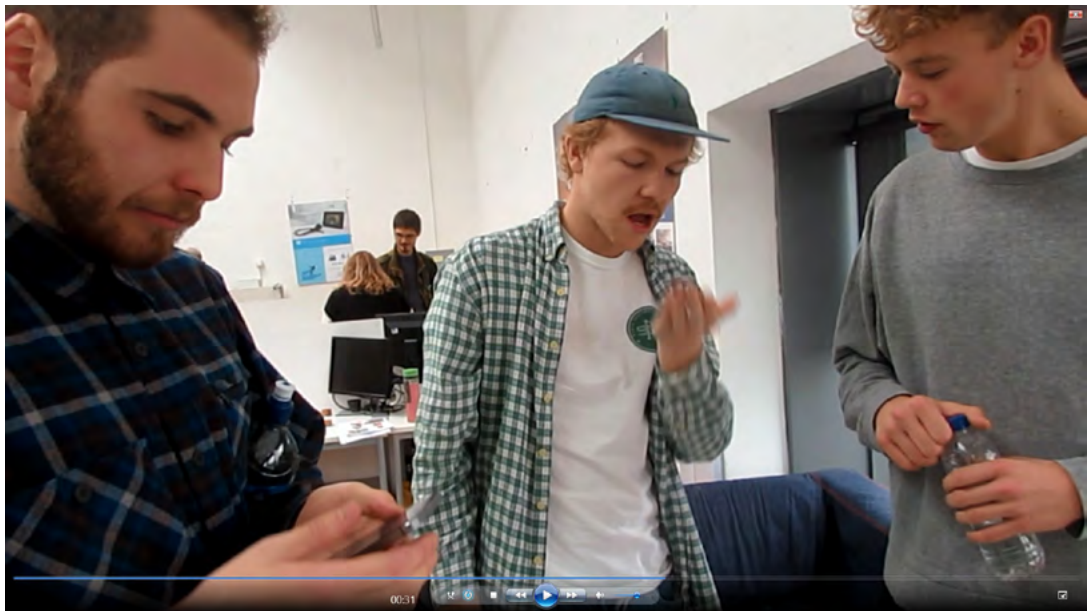
Thinking of potential people who will be interested.
I need more information!



Giving people bugs to eat



The most important thing noticed was that there were people who wouldn't want to try an insect, but when they see someone they know eating, they are willing! **Peer Pressure!**



ignore the alcohol



Survey?

I tried to design the survey in a way that could test how people’s feeling towards eating isects changes with knowledge on the topic and who are the ones more willing to try? are there some factors that make one person more open that another?

Future of food... yep, bugs!

"Eating insects could save the world!"

How do you generally feel about the idea of using insects as food? *

1

2

3

4

5

6

7

8

9

10

NOPE!

Yes! Yes! Yes!

Would you explain why? *

Long-answer text

Please indicate your level of agreement for the following statements. *

	Strongly disagree	Disagree	Mehh..	Agree	Strongly Agree
I consider myself outdoorsy.	☐	☐	☐	☐	☐
I love going camping.	☐	☐	☐	☐	☐
I love travelling to far destinations and experiencing local cultures.	☐	☐	☐	☐	☐
I have a bad fear of some/all insects and/or spiders.	☐	☐	☐	☐	☐

Please indicate your level of agreement for the following statements regarding environmental awareness. *

	Strongly disagree	Disagree	Mehh..	Agree	Strongly Agree
I consider myself an environmental activist.	☐	☐	☐	☐	☐
My food choices depend on how sustainable its sourcing is.	☐	☐	☐	☐	☐
I think about carbon footprint when shopping for groceries.	☐	☐	☐	☐	☐
I think about sustainability when shopping for clothing/cosmetics/consumer products.	☐	☐	☐	☐	☐
My products purchases depend on how low the carbon footprint is.	☐	☐	☐	☐	☐
I think about the environment when choosing my mean of transportation.	☐	☐	☐	☐	☐

Please indicate your level of agreement for the following statements regarding food in your life. *

	Strongly disagree	Disagree	Mehh..	Agree	Strongly Agree
I have a healthy and balanced diet.	☐	☐	☐	☐	☐
I love to experiment in the kitchen.	☐	☐	☐	☐	☐
I like cooking with or for friends - gathering them for dinner.	☐	☐	☐	☐	☐
The amount of protein I consume is important to me.	☐	☐	☐	☐	☐
I am willing to pay for high quality ingredients.	☐	☐	☐	☐	☐
I am interested in nutrition.	☐	☐	☐	☐	☐

Eating insects is good!

Cricket flour (ground dried crickets) has more than double the amount of protein in beef and it's at least twenty times more efficient source of food with significantly lower carbon footprint and needs for space, water and feed. It is highly nutritious not only in protein but fibre, wide range of vitamins and minerals and essential healthy fats. The taste is mild and nutty that many people seem to enjoy.

Power bar



Brownie



Banana bread



Cricket flour pasta



Having read the text above explaining the benefits, would you eat them? *

1 2 3 4 5 6 7 8 9 10

NOPE! ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ YES!

Would you explain why? *

Eating the whole insect, will ya?

Over the last few week I have been getting people to try freeze-dried crickets and cricket flour based products. The reaction of everyone that tried was rather positive. Nutty flavour and a pleasant crunch was what people most commonly described the experience.

Freeze-dried crickets



How likely are you to want to try some? *

1 2 3 4 5 6 7 8 9 10

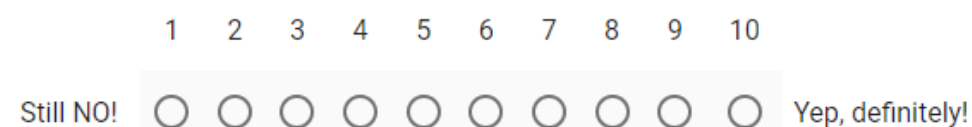
NOPEEEEE! ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ I really want to. / I have already tried!

And why? *

Your answer

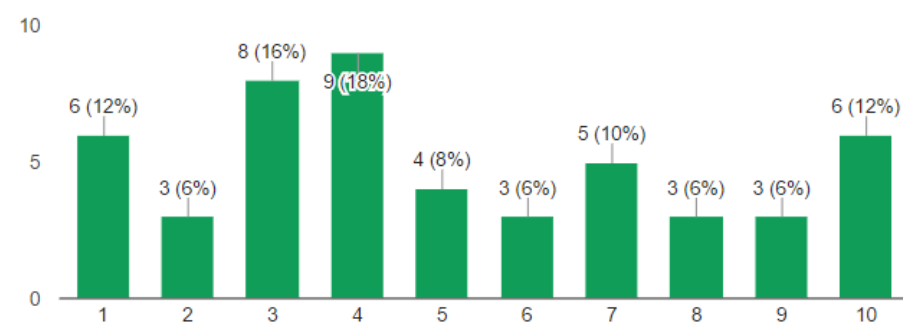


Will you be more willing to try insects if it was part of event at your workplace or a conference and everyone around you was eating and liking them? *



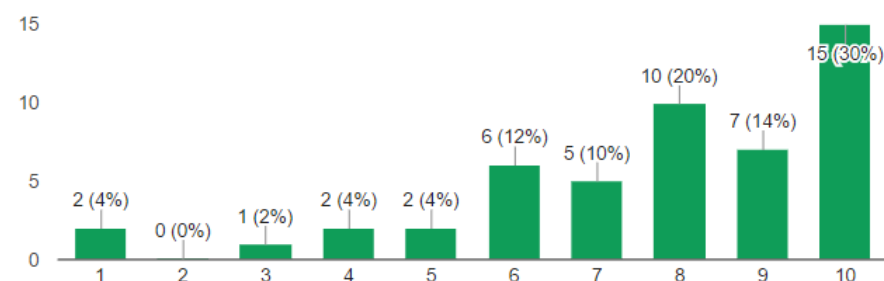
How do you generally feel about the idea of using insects as food?

50 responses



Having read the text above explaining the benefits, would you eat them?

50 responses



Results

RESPONSES

50

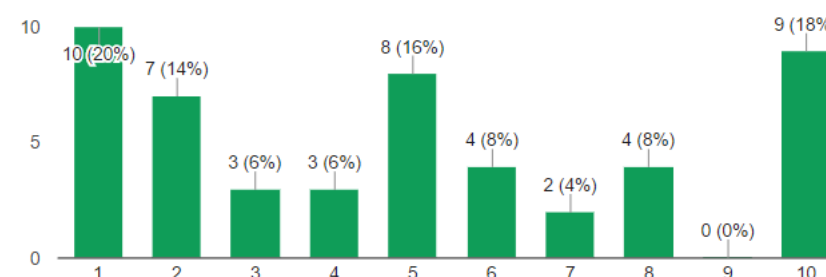
It turned out that educating people about the benefits of Entomophagy and letting them try it in social context are the two most important outcomes from user testing.

Getting vegetarian friends eat my home roasted crickets* made me decide on vending whole crickets.

Eating the whole insect, will ya?

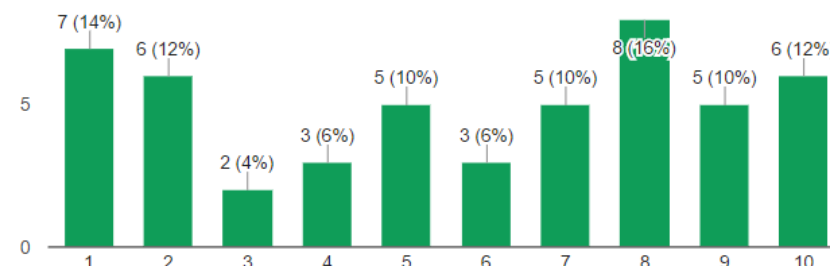
How likely are you to want to try some?

50 responses



Will you be more willing to try insects if it was part of event at your workplace or a conference and everyone around you was eating and liking them?

50 responses



Collaborations

2nd visit to Patisserie Maxime and interview with the owner Cyril

Geri: Will you keep up with insect cakes after Halloween?

Cyril: to be honest there aren't a lot of suppliers out there.. **And the price is quite high - 100 times more expensive than normal flower for me - I would like to continue and work with it, but it's not so good for the business** - after all we need to make money

Geri: Entomophagy and world food issues?

Cyril: there's been a couple of students researching into that - they went on radio and talked about the subjects. I found that it was quite interesting - the truth is that if you want to get the right nutrients, I don't think the meat we're eating now is great. If the people on the planet is going up we cannot continue like this, we cannot cope with the demand - it's better for us look at something . If the majority of the people on the planet are eating it, why aren't we. I know it is a psychological barrier, but at the end of the day is meat that is easily accessible and nutritious cheap - we should be stupid not to eat it. We buy expensive meat that's not very good... The last student, Courtney - she tried to integrate insects in cupcakes. **There are a lot of resources in the United States and in Australia, but not so much here.**

As you say - it doesn't take that much space or energy to breed them and brings a lot of nutrients. So we need to break that in a bit. I found it was a good way to do it with cakes, and I thought it would be good time to do it over Halloween, cause people's reaction would be much worse, I think, if I had introduced them in July.

Geri: How has it been so far with the insect cakes?

Cyril: It's a good sale but it's extra work for us as well.. **People coming from all over the UK here... and magazines and press, even just to talk to you!** I mean, I'm really happy to help you, it's just crazy... and we don't want to let anyone down.. And today I got an e-mail - one of the many "Oh, I'm coming over to Edinburgh with my family next Saturday because my daughter really wants to try your insect cakes, but she's gluten and dairy free, do you think you can make something for her?" It's good you know, we can, but it's extra work, we want to please everyone, at least people are getting interested into that and I think your idea is good - we need to find a way to get more audience, more people interested.



If you want to please people you give them cake with insects without making it so obvious, although for mealworm brownie the selling point is that you can see them - it gets people interested

Geri: do you think that if there were no mealworms on top, but just cricket flour in more people would buy it or less people would buy it.. Or different people would buy it?

Cyril: **Actually, I don't know. But probably a bit less, because the mealworms makes them scared but at the same time it attracts them.**

I think that if you grind them, it's the first step to make them more easily accepted - people try it in something and see that it doesn't taste that bad, then want another one, and then they might be more keen to try something that is more obvious - don't go too obvious with the first step and progressively it gets more.

The supplier was very popular with the chocolate covered locusts, they were always out of stock - but i buy locust, i make chocolate and make them myself!

People are scared of trying the naked insect, people want the familiar taste - why is the brownie most popular - because everyone knows what the brownie tastes of.

I think that if you create that thing on your own, i think, as a business idea, it should work

The more people there'll be, the more product on the market - and we're starting from almost zero

There's this event in January - down in Cambridge, there wouldn't be those conferences if there wasn't any interest. In the last years there's been more talking more talking, the awareness it being raised - the majority on the planet is eating, we aren't. But we people tend to go with what's popular - so if people start eating them here in the west, more people will start eating them.

Geri: do you consider suppliers outside of

the UK, Crunchy critters are getting their bugs from Thailand

Cyrl: When I run a business like that I need something quick, **I cannot wait for delivery from Asia.** I came up with the idea for bug cakes a week before when i wanted to start it. So i ordered quick and I got them 2 days before the starting day and spent a long time cooking and trying

Geri: was it easy to integrate them cricket flour into the recipes?

Cyrl: **cricket flour is easy, very nice, it doesn't change the consistency much.** In the brownies we put 30 percent cricket flour - the brownies are very popular - people come here and buy 8.. The idea was really not to make money, but to interest people. So we wanted to keep the price down - 1 pound take away, 1.5 sit in. But if we wanted fare price with the same margin for the product as for other products we sell they would be veeeery expensive.

Geri: Do you think you'll be interested in growing your own bugs here, for the patisserie:

Cyrl: yeah, why not - **i have that space in the basement, so I would love to breed some here - if I get a cheaper price per kg of crickets - of course!**

Geri: did you expect so much media interest

Cyrl: you know, not really, we posted 4 posts on facebook and on twitter two days after we've started it, and on the same day BBC

wanted to come and make coverage.

But i think the tweets were quite clever, the message we wanted to transmit.

People needed to understand why. After we explained it was much better. Even just the printed A4 sheets - people understand and buy it.

Geri: What about your customers? Who are they?

Cyrl: I would say people are fairly young.. Veeery rarely above 60, or 50.. **Most people in their 20s and 30s.. But both males and females.**

Generally people were either Yuck or curious to try it. But what was good that there are people that are interested in eating insects generally - like you, and they were happy to understand that there were things happening because of the press.

But i think the crickets it's a very good business opportunity! I think it's a very good idea! I think there's big potential and market for your project much beyond good grade at uni. I think you should start from businesses. Target businesses - then people try insects in a restaurant or cafe - and they then become interested and then they buy your product.

Cause if they don't know how it tastes, will they want to buy your product? They won't want to spent all those money.

Tell businesses - please take some of my insects in your menu, you as a supplier.

Ian Watson chat

Ian Watson wanted me to write a paper with him on algae as feed. Experiment with growing crickets on different diets and seeing how it affects their development. It was an exciting idea! ..but got lost in the process.

He also suggested to find me a Spirulina supplier, so that I can grow it and experiment with that.

Next meeting he suggested Euglena!
See on next page.



Crunchy Critters Nick

Nick - the owner of Crunchy Critters, really enjoyed my video and wanted me to potentially film more for them.

I asked about the presentation down in Cambridge. Might be invited

They have started 4 years ago and over the last two the interest's been growing a lot.

Users:

School - food of future subject

professional athletes

Grubs kitchen

Will chat



Will is a last year PD student who actually grew crickets in the studio.

We chatted on skype for few hours and he gave me the courage to do it myself.

He was using piping with hot water to keep the crickets warm, which seemed a bit excessive.

It was really helpful though :)

Spirulina -> Euglena

The contribution of livestock production towards environmental pollution is becoming of great concern because of the emissions of greenhouse gases, such as CO₂, CH₄ and ammonia. In addition, the production of CH₄ during the enteric fermentation of feeds in the rumen is correlated with the loss of gross energy (GE) from the consumed feed (Szumacher-Stabel and Cieslak, 2012). Thus, identifying alternative solutions to this major constraint is a concern of both environmental protection and nutrient utilization. The efficiency of ruminal fermentation can be facilitated by modifying the feeding system using natural feed additives, thereby reducing the emission of greenhouse gases and enhancing the efficiency of nutrient utilization.

Microalgae are one of the most promising biological resources, as these organisms are rich sources of vitamins, minerals, proteins, polyunsaturated fatty acids, antioxidants, etc. (Pulz and Gross, 2004) and can be used to enhance the nutritional value of animal feed, reflecting the well-balanced chemical composition of these microphytes. The inclusion of microalgal biomass in small quantity positively affects the physiology of animals, as antibacterial action, improve gut function, feed conversion and reproductive performance have been reported (Harel and Clayton, 2004). A number of nutritional studies have demonstrated the suitability of microalgae biomass as a potential substitute for conventional protein supplements, such as soybean and fish meal

[http://www.animalfeedscience.com/article/S0377-8401\(15\)30085-7/pdf](http://www.animalfeedscience.com/article/S0377-8401(15)30085-7/pdf)

Spirulina -> Euglena

The humble euglena gracilis is tiny, green and very strange: Part animal and part plant, the darting little long-tailed beastie can be found by the millions in nutrient-rich freshwater ponds.

euglena are one of the very few animal-like creatures on Earth that are capable of photosynthesis

This hybrid status gives euglena some highly unusual properties: While it can survive and thrive on carbon dioxide, water and sunlight like a plant, it nevertheless produces both plant and animal lipids and amino acids, making it one of nature's few "whole" sources of fat and protein — the omnivore's solution, if you will. As if that weren't enough, it also manufactures a unique starchlike carbohydrate, paramylon, that shows signs of effectiveness in boosting immune systems, reducing cholesterol and moderating insulin response when used as a nutritional supplement, plus a rich array of anti-oxidants like beta-carotene and vitamins C and E.

both plant and animal nutrients

<http://blogs.wsj.com/speakeasy/2013/07/25/is-this-the-future-of-food/?emailToken=JRr8cPh8YnqegdU0aswW8BgTQ4NNVLH RHw0%3>

A single gram of the algae contains:

Beta carotene equivalent to 7 pickled plums (50 g)

Vitamin B12 equivalent to 50 g of cow liver

Folic acid equivalent to 1 sardine

Zinc equivalent to 50 g of clams

DHA equivalent to 50 g of broiled eel

can't find the report

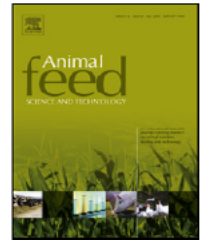
<https://www.euglena.jp/en/solution/>



Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci



Short communication

Effects of Euglena (*Euglena gracilis*) supplemented to diet (forage: concentrate ratios of 60:40) on the basic ruminal fermentation and methane emissions in *in vitro* condition



Each cookie contains about 200 million euglena, which means about one billion green bugs are packed into each box. According to Izumo's report, 50 grams (about a 1/4 cup) of a Euglena bar or cookie could supply a child with all the vitamins, minerals, and protein he or she needs in a day, for just 10 cents. To the best of my knowledge, a sweet potato can't pull that off.

<http://motherboard.vice.com/blog/japan-wants-to-feed-the-world-with-tiny-green-bug-like-creatures->



soylent Euglena, an all in one algae

Nutrition

28 DAYS LATER



Syntax

Aug '13

I'm fluent in Japanese and even the **Japanese information on Euglena is severely lacking**. They have a list of nutrients that are provided by the organism, but the only measurement that they list is how much of the organism itself is in their products. I haven't been able to find more than that.

From what I can tell, even if they did get their act together and do proper nutrient accounting, it would just be a supplement, because their vitamin and mineral lists are not complete. (No choline, calcium, chromium, molybdenum, iodine selenium, sulfur, etc)

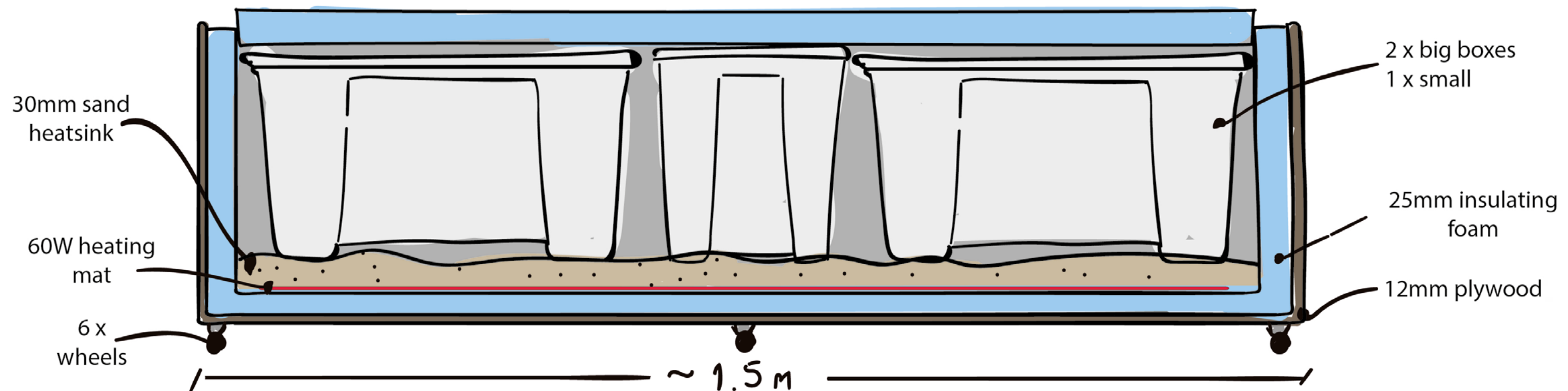
It may be more cost effective at that point, though, than using multivitamin supplements. That would be good, and I think that's their point. I don't think their goal is to replace food, but to add this to food to prevent common nutritional deficiencies.

Breeding crickets, Growing Spirulina

In order to build the ultimate cricket farm i need to build the DIY cricket farm, to understand them a bit better, cause it doesn't matter how many videos i watch or papers i read, i won't know nearly enough until i breed them myself :)

Same for the Algae.

Watching numerous videos and reading quite a few papers on rearing crickets I got enough information to build my own farm and breed my own crickets



I decided to rear my crickets in IKEA plastic boxes and bought 3 - 2 big and 1 small for babies :)

I was about to put them in a bigger container that had to maintain the temperature. Hesitating between different methods of heating up the farm I decided on heating matt used for reptiles.

From research, the optimum temperature for breeding crickets is around 30 degrees Celsius.

Did a quick calculations and with temperature differences and energy needed to warm the space up and decided this 60W matt will do the job.

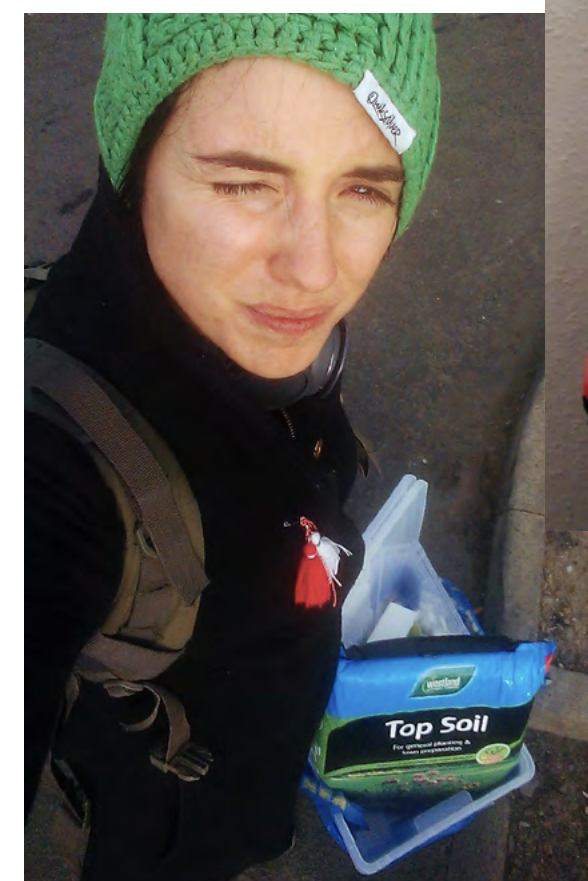
Alan suggested I used sand to distribute the heat properly and said that was really important to get dry sand. I tried.



Having ordered some of the other necessary components for the cricket farm online, I had to go to IKEA and get the big boxes, since they were the main missing 'ingredient' to proceed.

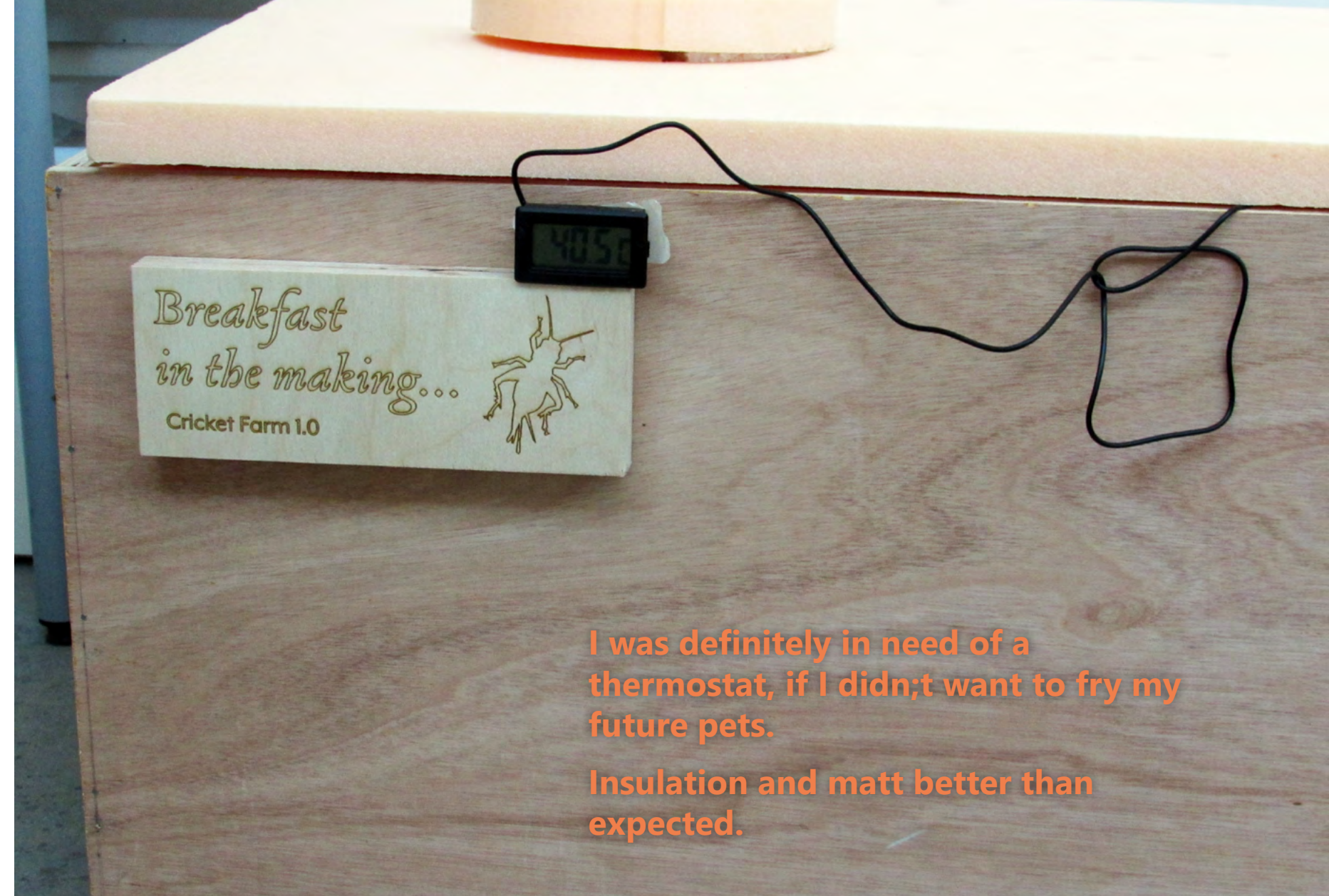
Not the most comfortable to carry, I had prepared myself that it wasn't going to be the easiest trip ever. Aaand I had the flu on top of it.

I hadn't planned it, but seeing Dobbies, a big garden centre, I got reminded that I need to buy Top Soil for the crickets to lay eggs in and potentially water granules to keep it moist and maybe using it as water supplier for the insects.





waiting for foam



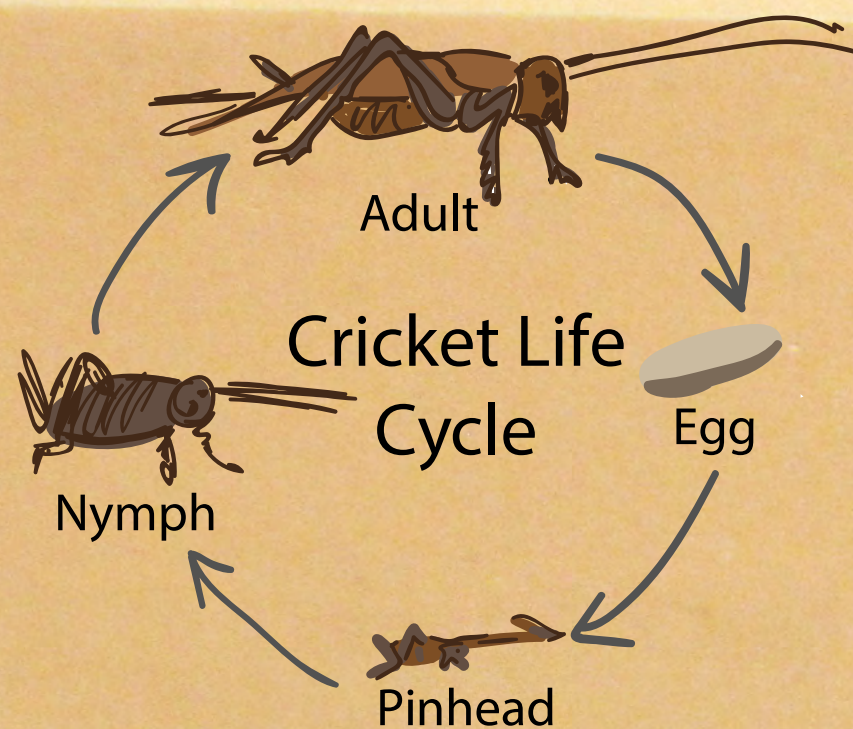
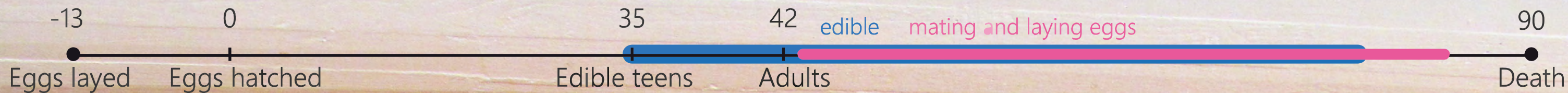
I was definitely in need of a thermostat, if I didn;t want to fry my future pets.

Insulation and matt better than expected.

Please watch:

<https://www.youtube.com/watch?v=1SP-ZrXvrBI&list=PL7PnjWahoc93AojvviQb9rXDfXqJxEWJ4&index=4>





User and PDS

Autonomous and fully automated cricket and algae farm with cricket flour and dried crickets dispenser.

- For the office
- For open-minded people's homes
 - Athletes
- "The kettle of every home on Mars"

goal: 200-500g
per 10 days...
not sure :D

just an example

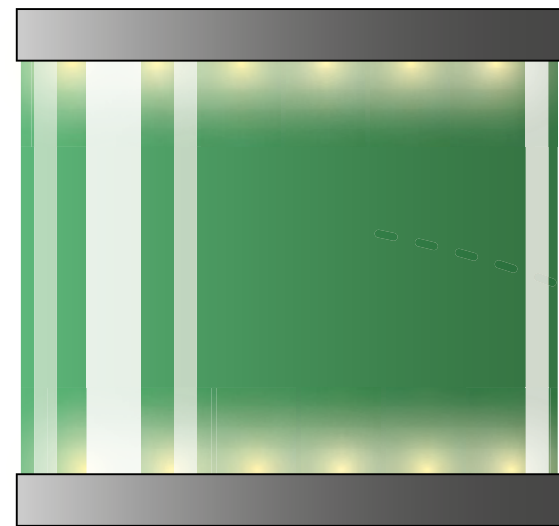
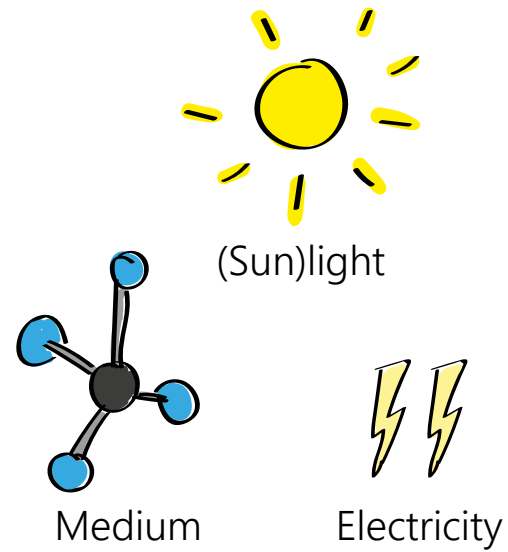




The idea is that the user can only see the crickets when they want to - smart glass!

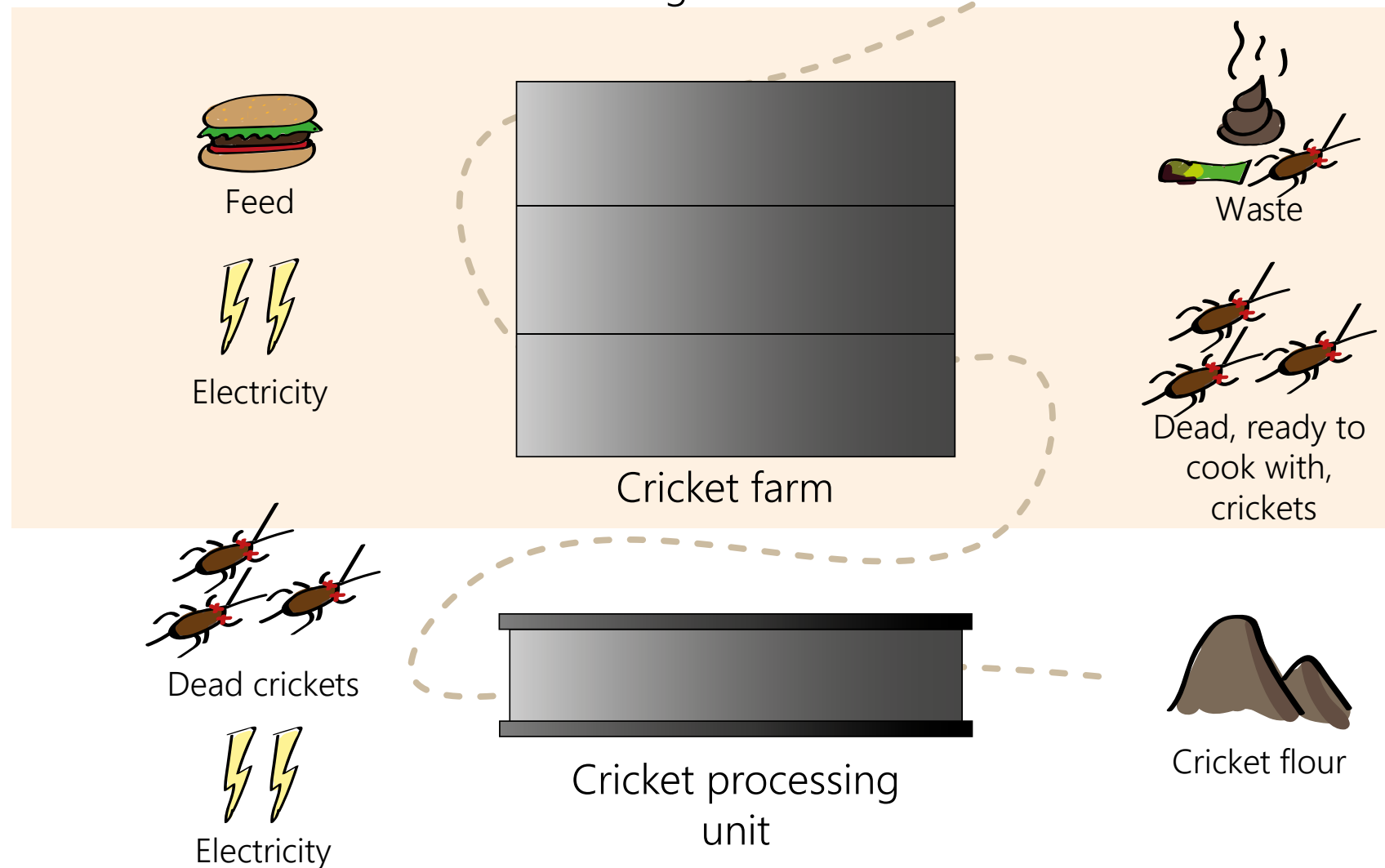
Modules:

Inputs:



Algae farm

Outputs:



Before I go in the Define phase this is what I thought I wanted to design.

Since the algae was another system, I decided not to concentrate on it.

Same for the cricket flour making.

I wanted to concentrate on the automated cricket farming and the challenges that come with it and try to solve them in an ingenious way :)

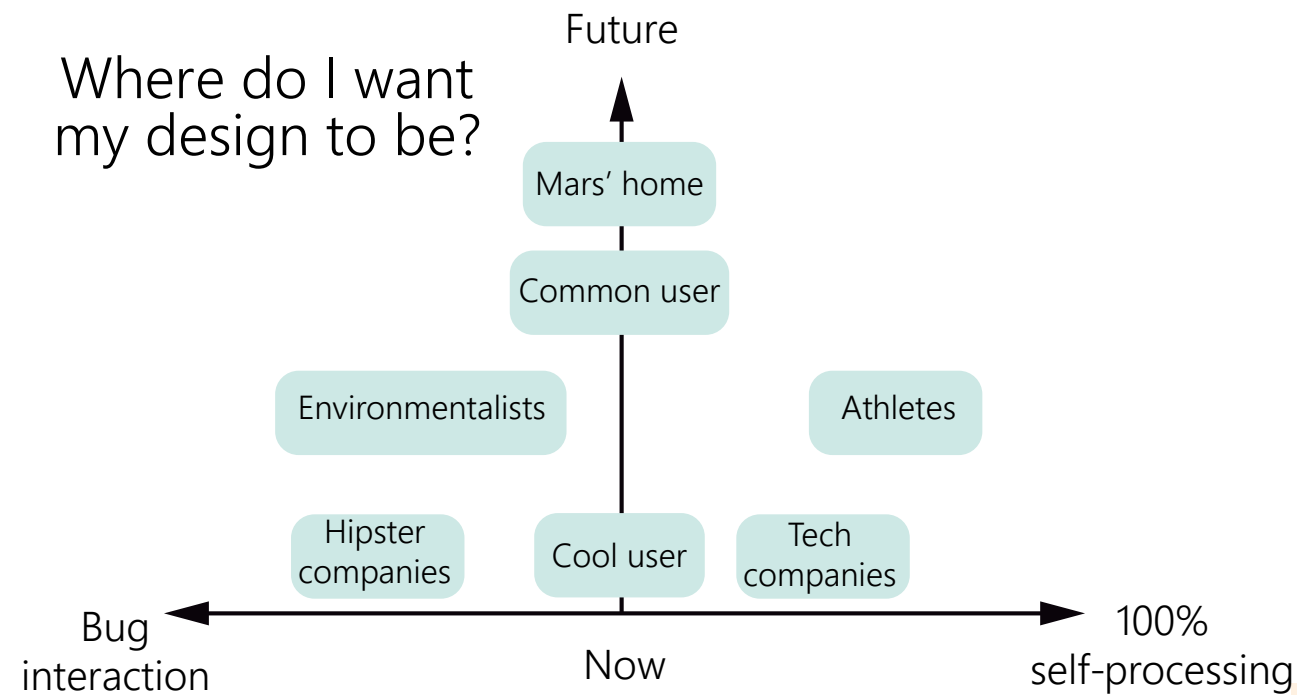
no algae

Define

Mechanisms and Structures	54
Whole Crickets Vending Machine	59
User Journey	64
From Pre-submission presentation	75
Product Design Specifications	86

Probably the most important chapter and the worst justified one. It condenses all the insights from the Discovery phase to decide on product specifics. Defines key design requirements.

Now what?

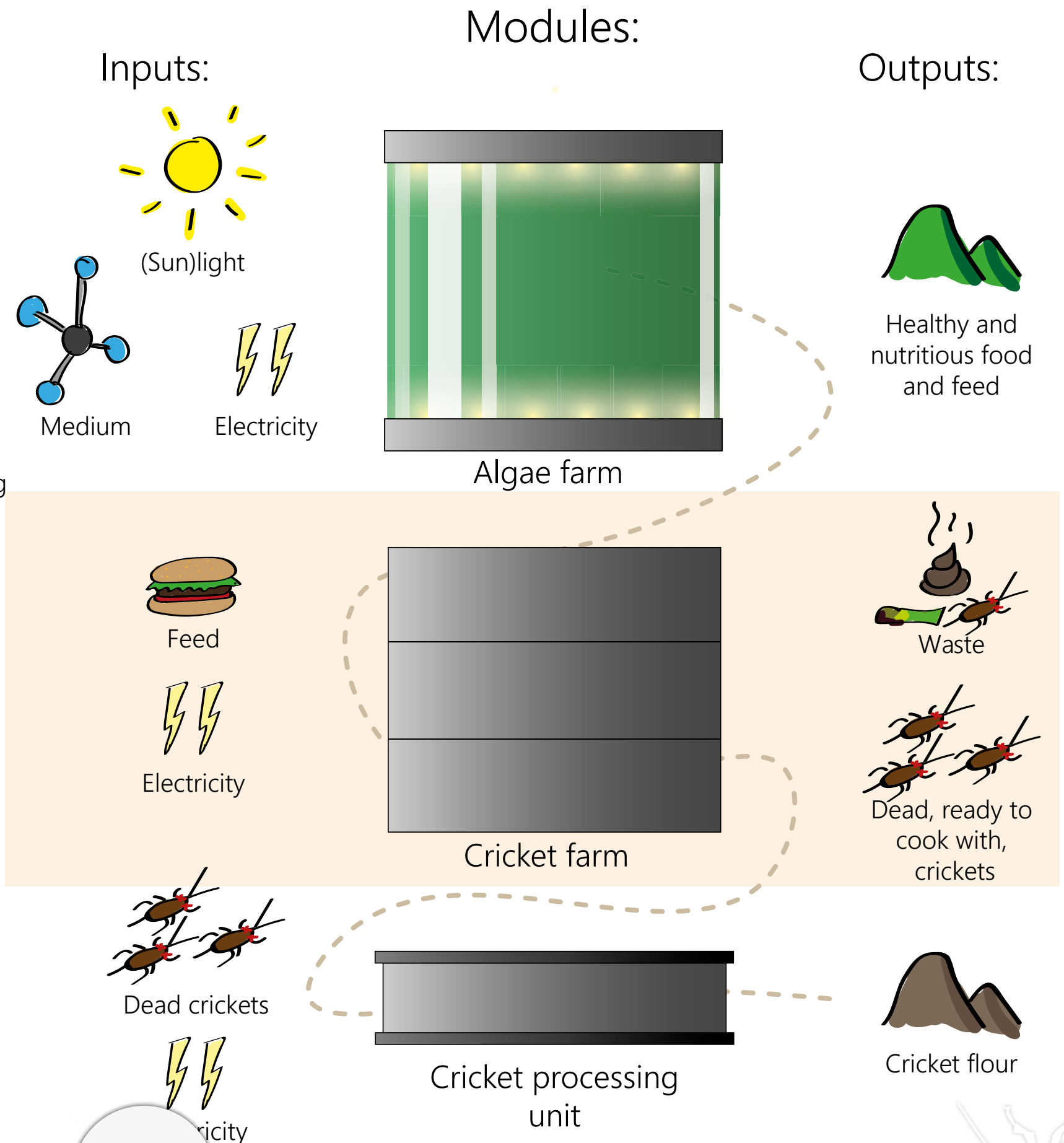


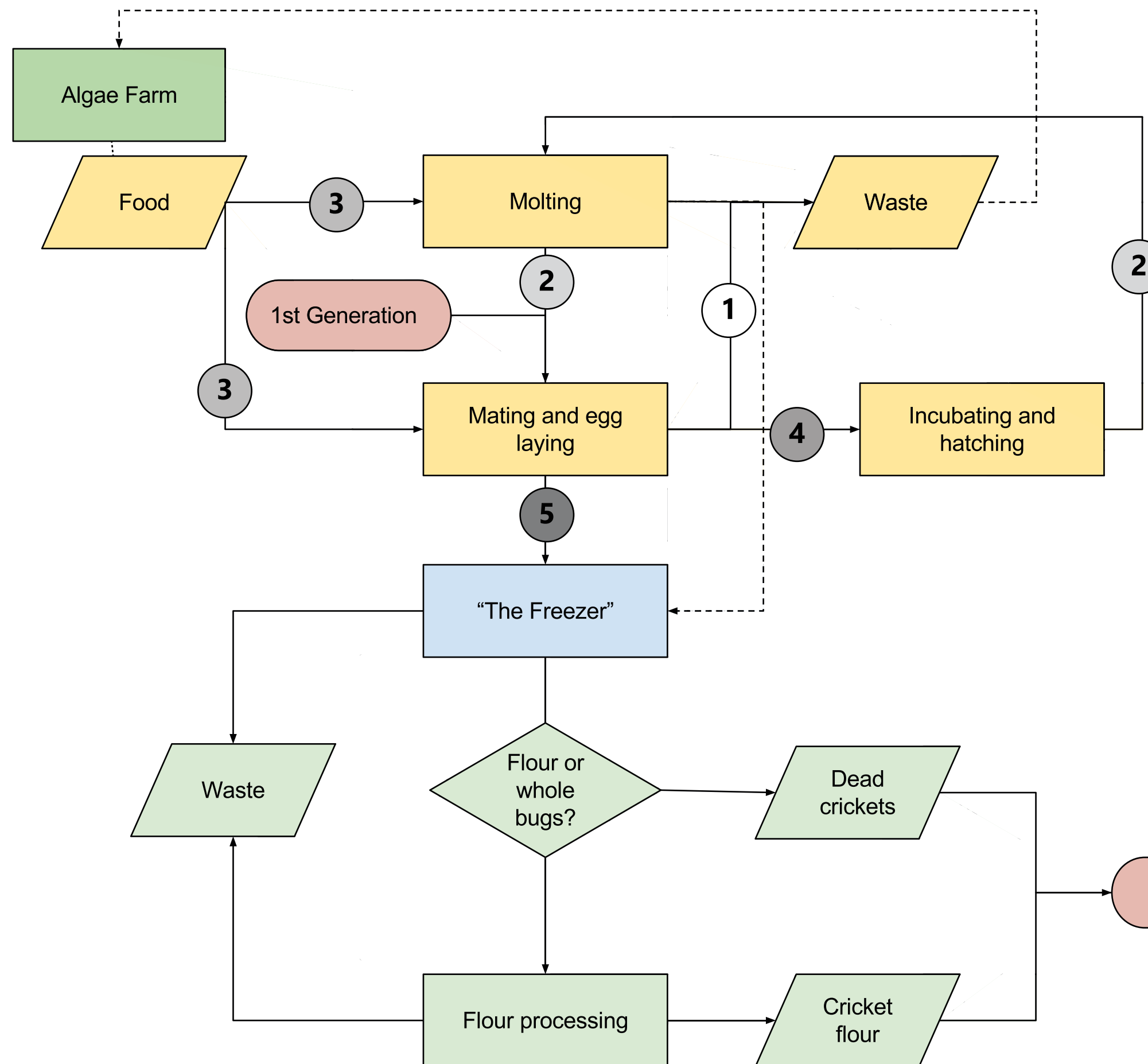
While who the user is required a valid question, it was time to start solving issues.

Cricket farm.

What have I learned from farming crickets and how can I make it smarter?

The system flow diagrams explain all the processes that happen and what needs to be solved.





Adult crickets eat baby crickets! This is why they need to be kept separate. 4 shows that after the eggs have been laid they need to be moved to hatch.

Moulting cage is for is when they are teenagers and changing skins. And then there's adult one. All of them produce waste and need feed.

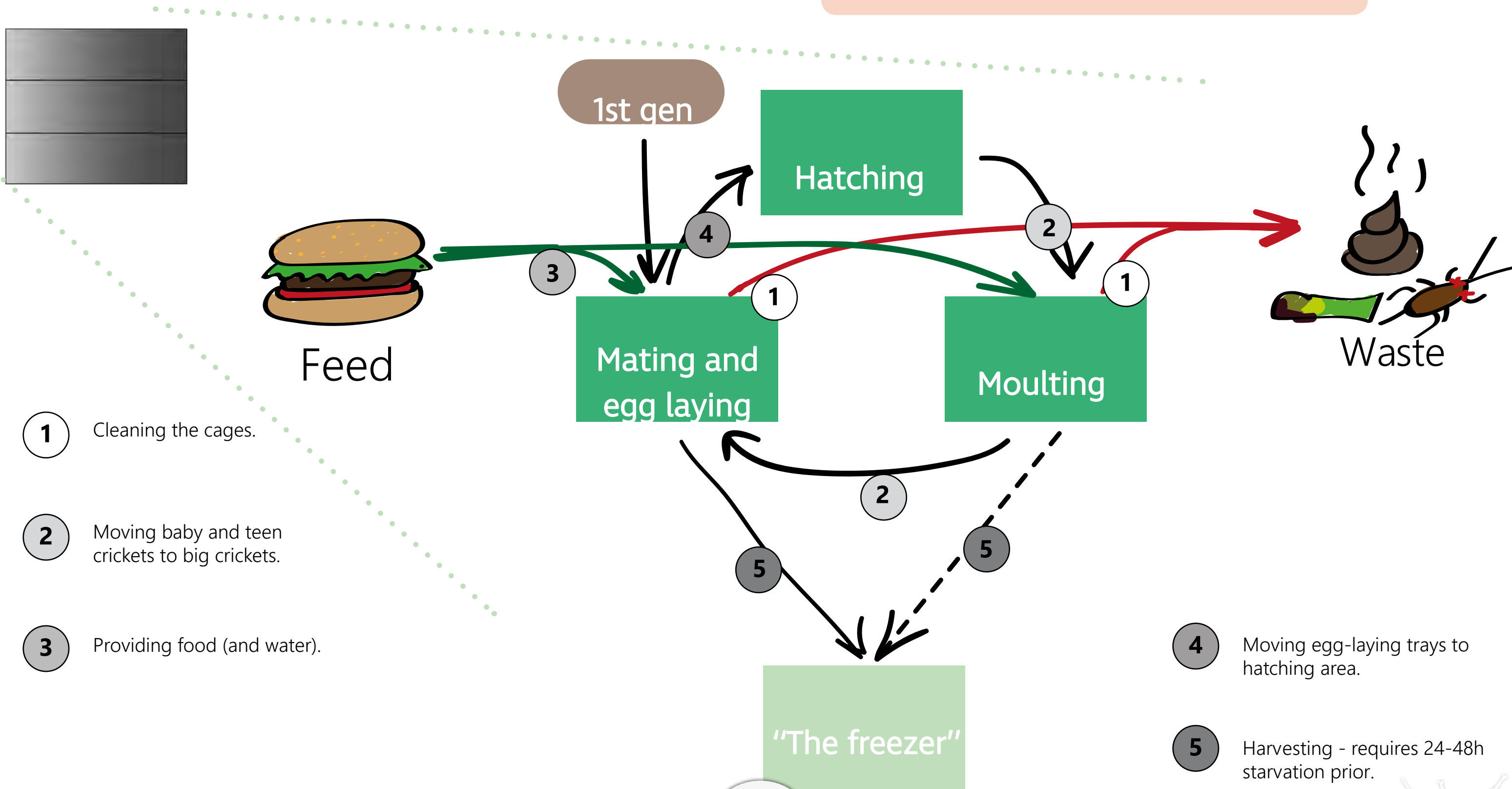
Hopefully waste can be used to feed the algae, which will feed the crickets.

Harvesting is an important moment with freezer used to kill them. Then user decided whether they want the whole bug or flour.

- 1** Cleaning the cages.
- 2** Moving baby and teen crickets to big crickets.
- 3** Providing food (and water).
- 4** Moving egg-laying trays to hatching area.
- 5** Harvesting - requires 24-48h starvation prior.

simplified diagram - what happens in the most important machine module?

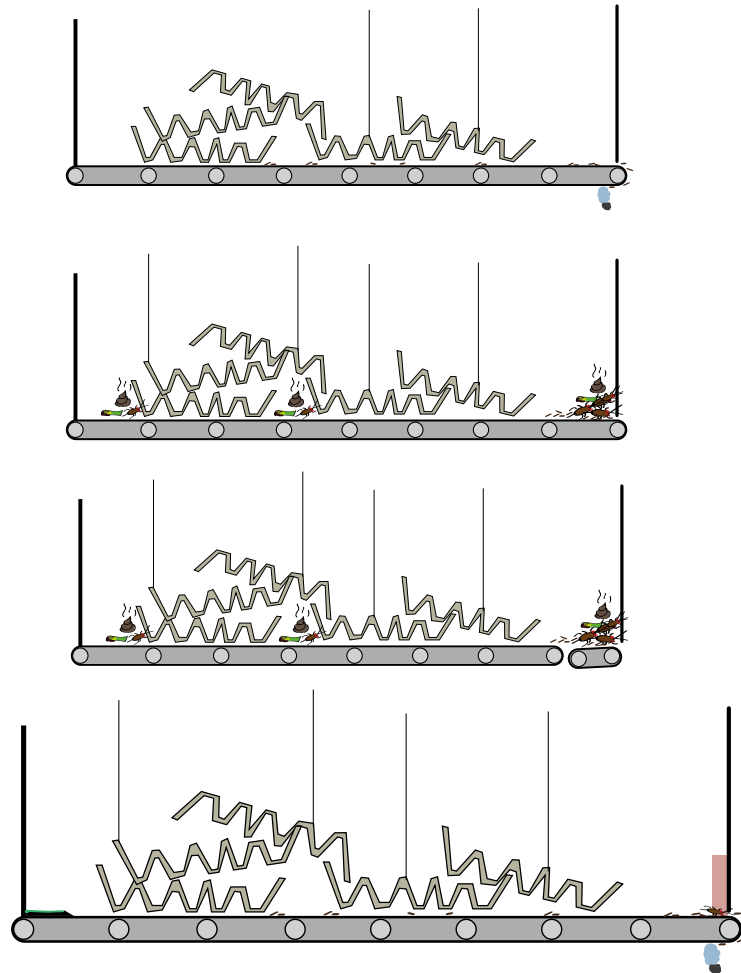
In biology, **moulting**, also known as sloughing, shedding, or in many invertebrates, ecdysis, is the manner in which an animal routinely casts off a part of its body (often, but not always, an outer layer or covering), either at specific times of the year, or at specific points in its life cycle.



1

Cleaning the cages.

1. "Moving Floor"



Mechanisms and Structures

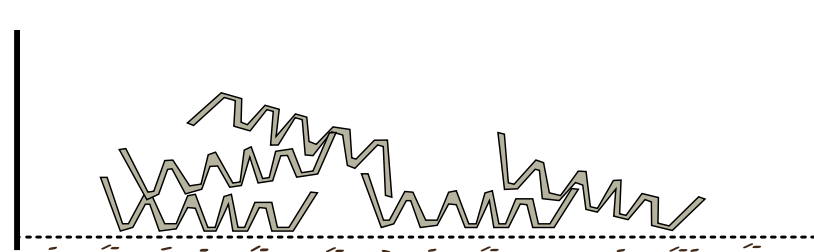
If I wanted to create a truly efficient cricket farming machine, I had to farm maximum insects per minimum volume.

Cleaning is important. All the research confirms it. Not that excrements are dangerous and carry diseases. Crickets just feel better and grow healthier when clean.

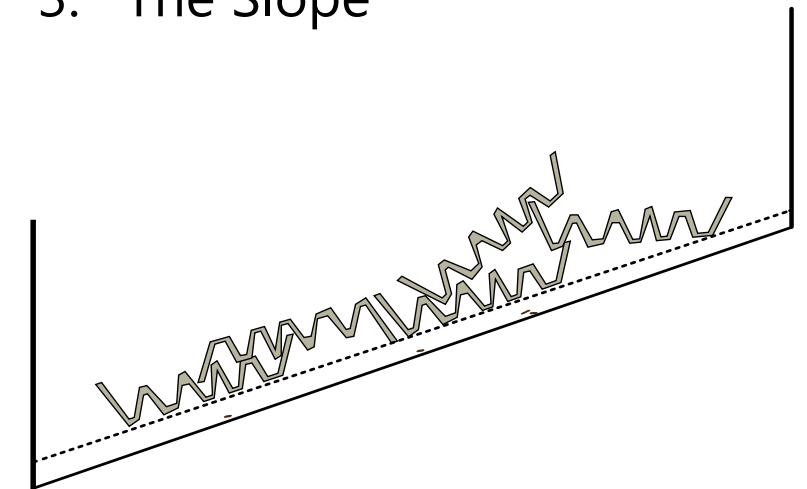
All previous cricket farmers suggest moving crickets from one cage to another every few days. To me that simply meant - 2 volumes of space for 1 volume of crickets.

It was important for me that I come up with a way to **clean the cage without moving the crickets!**

2. "Mesh."



3. "The Slope"



As much as a mesh underneath seemed like a smart idea. Just needed to find the right material for the task (non stick, probably teflon) and it seemed like resolved, there was the problem with thickness of the holes - crickets not going to waste area.. but they also shred their skins which are waste but as big as a cricket..

I feel for the conveyr belt idea. Having the furniture suspended also meant that i can use the ropes to harvest them!

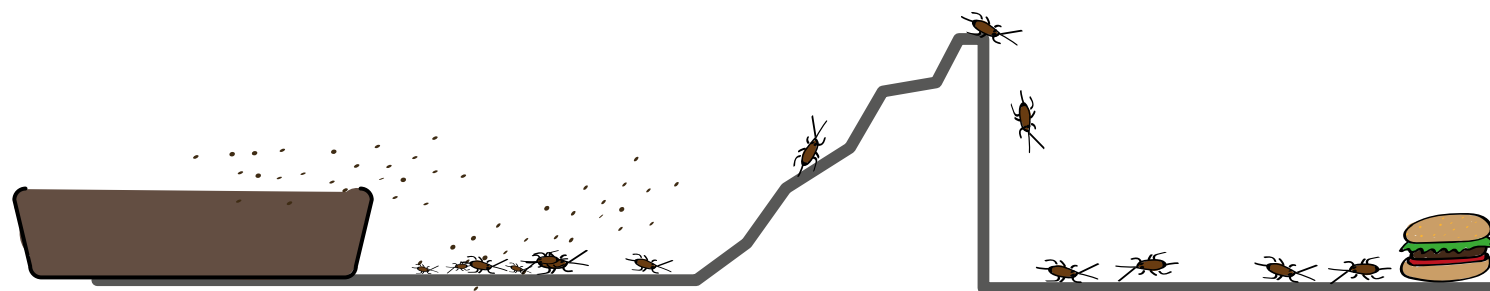
It was time for some experiments and prototype building :)

But first, lets try and solve the other operations needed for an automated cricket farm.

2 Moving baby and teen crickets to big crickets.

2.1. Use the 'Ferris Wheel' system from 4. - if crickets are old enough to climb up the tray - they deserve to be with the adults :D

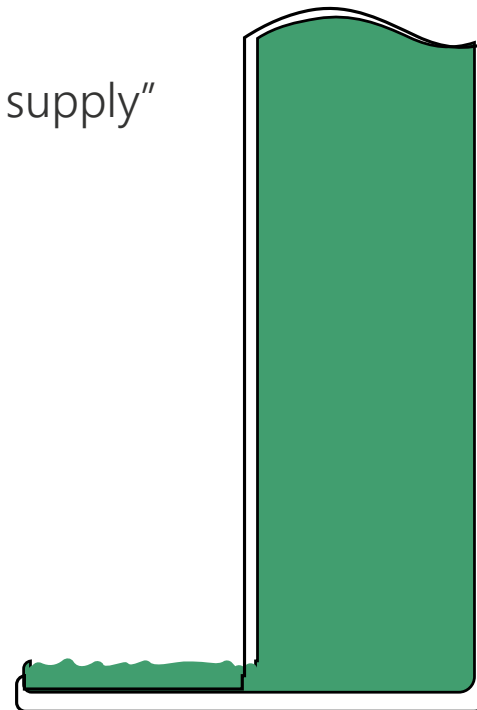
2.2. "Ramp to Mamma"



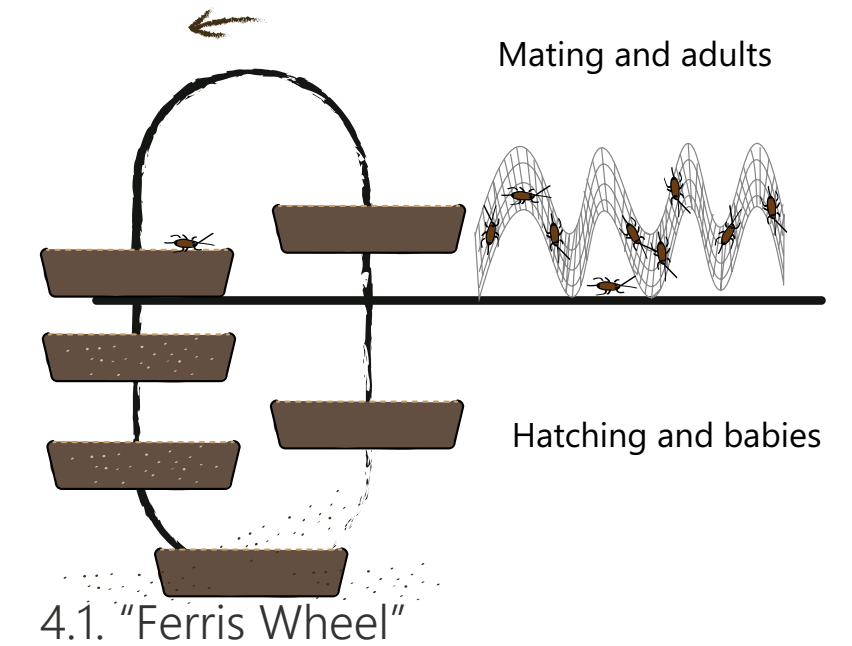
Somehow ensuring that the teenager can join the old crickets only when they are grown up enough not to be in danger.

3 Providing food (and water).

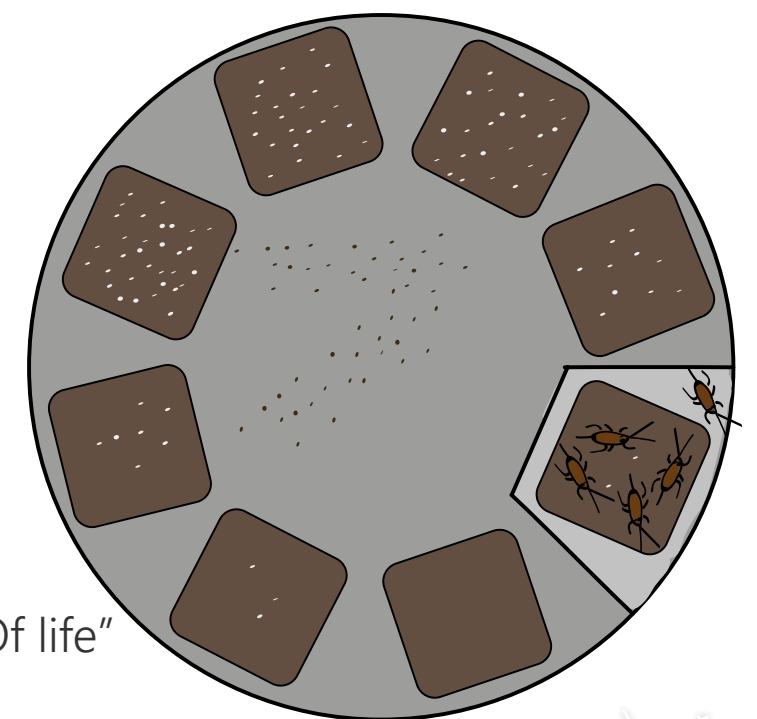
3.1. "Neat food supply"



4 Moving egg-laying trays to hatching area.

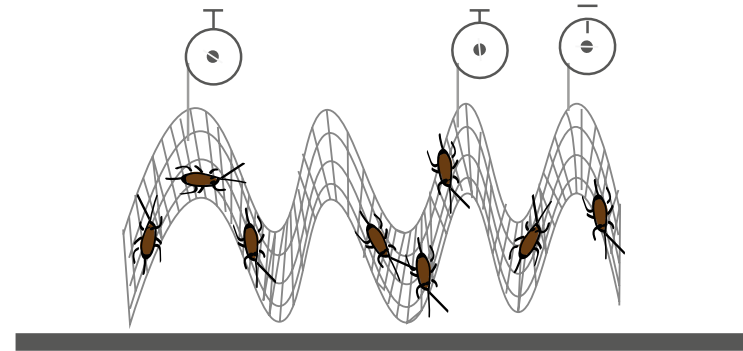
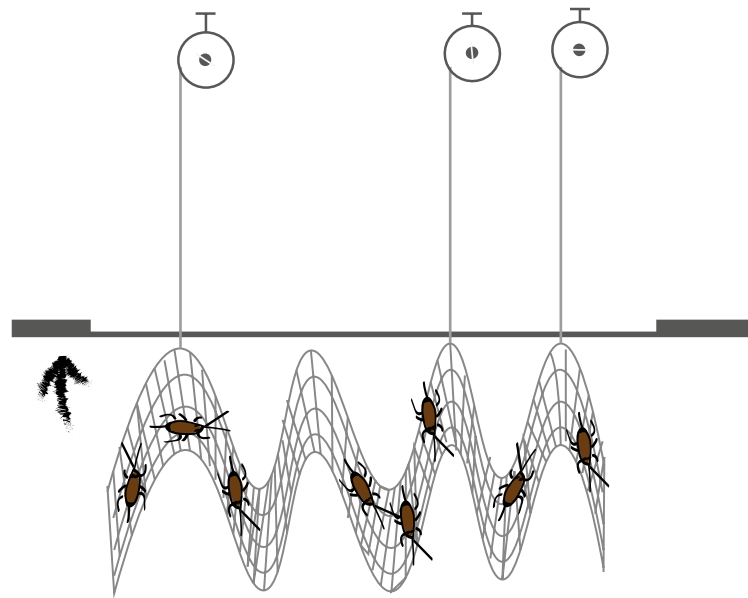


4.2. "Circle Of life"



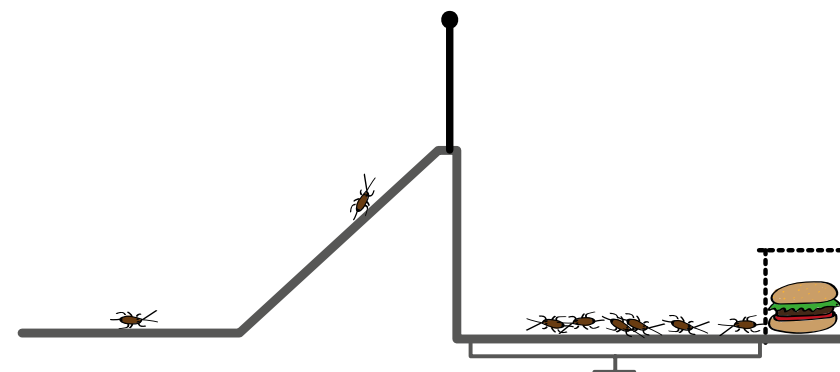
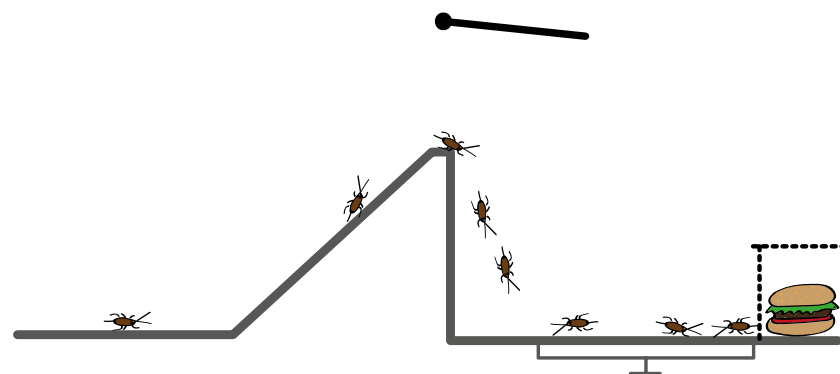
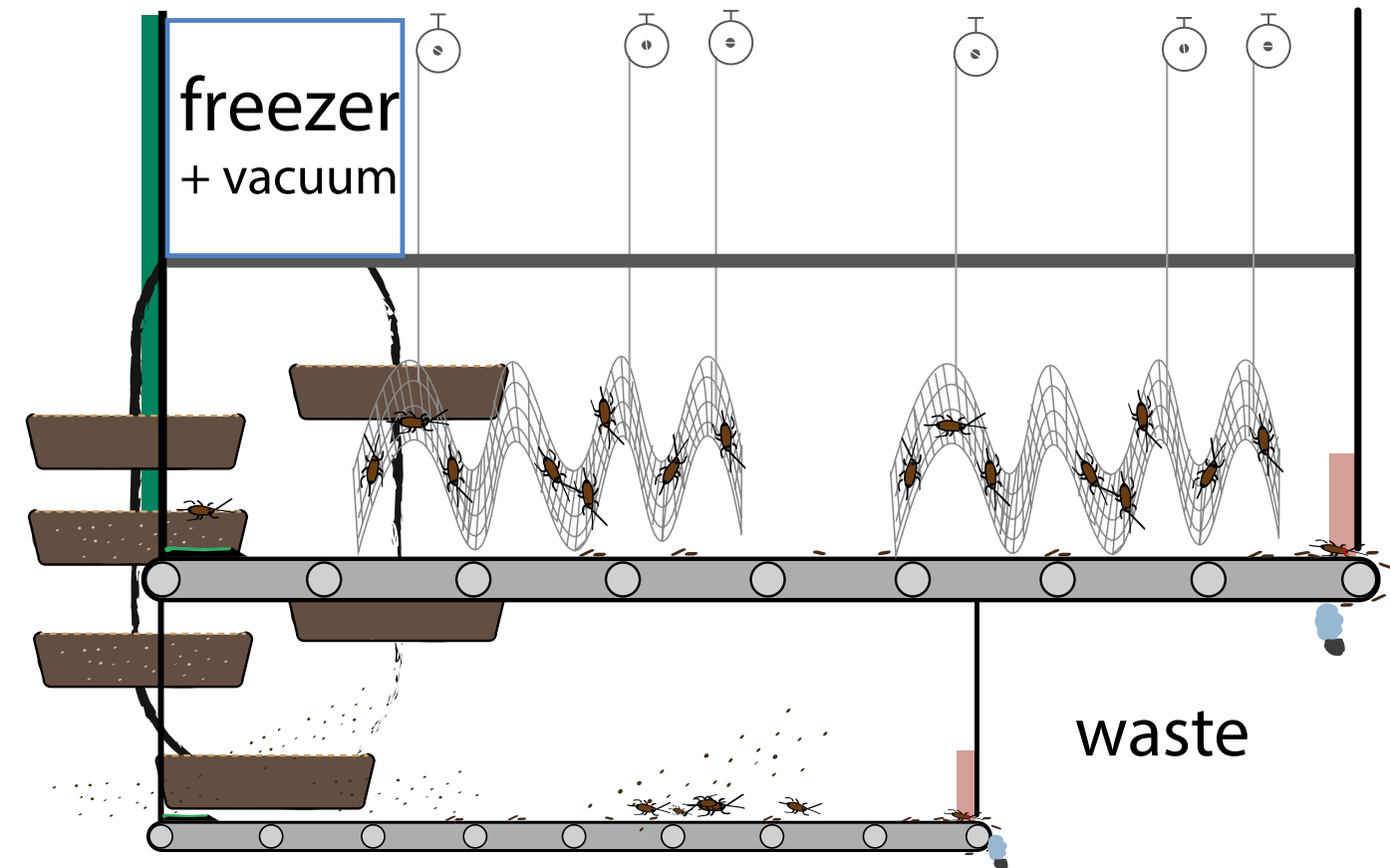
5

Harvesting - requires 24-48h starvation prior.



Starve -> freezer

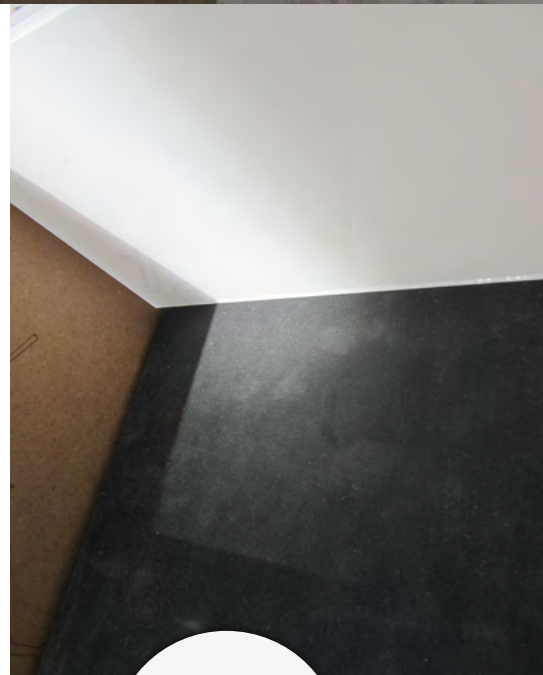
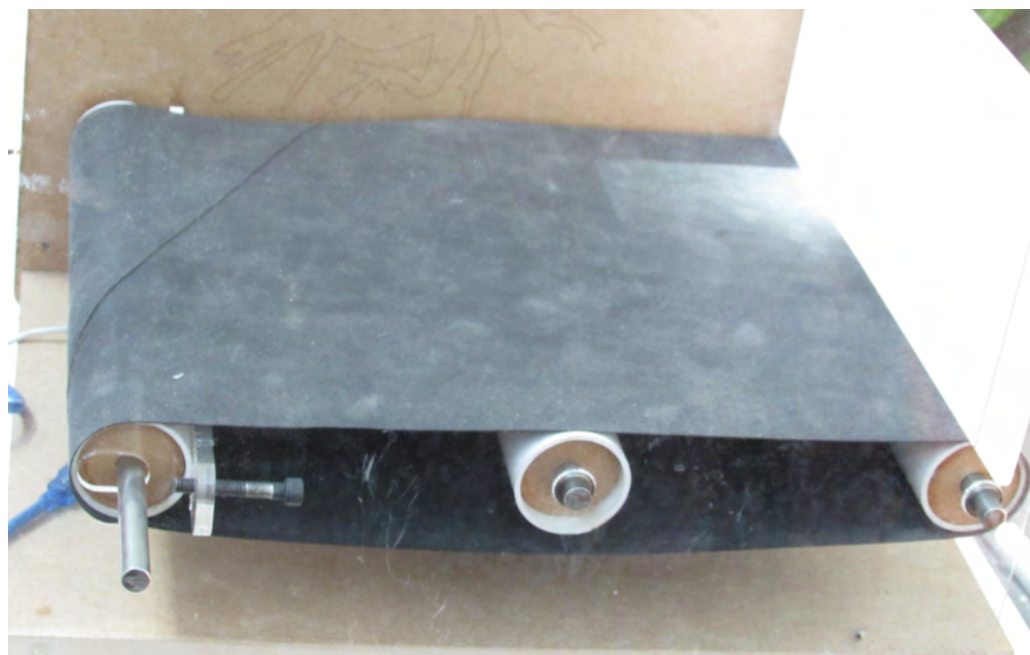
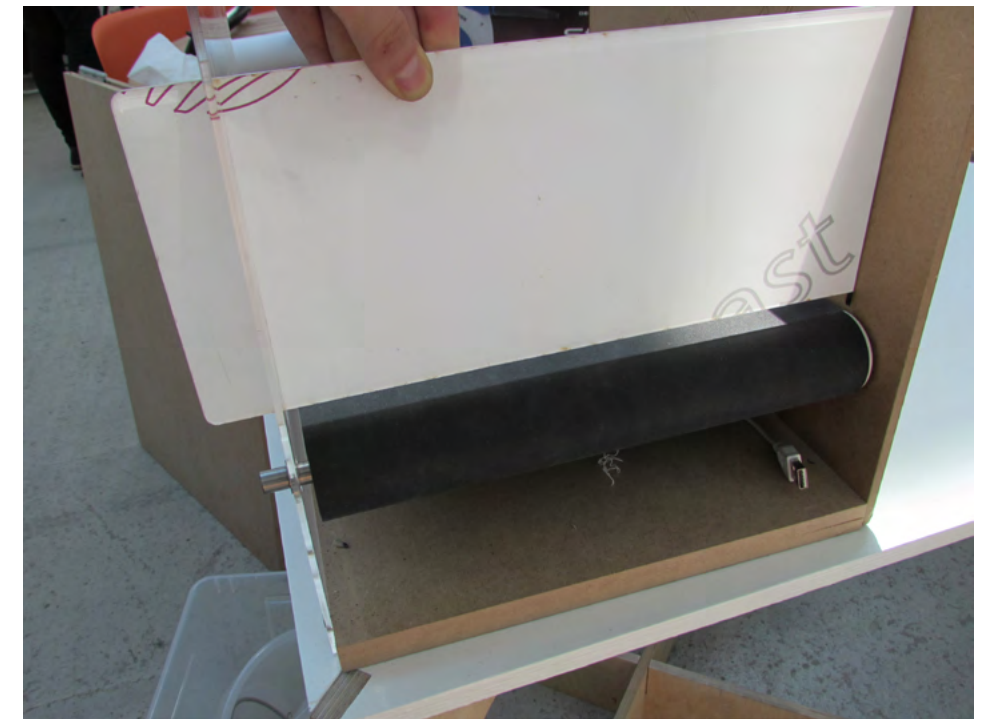
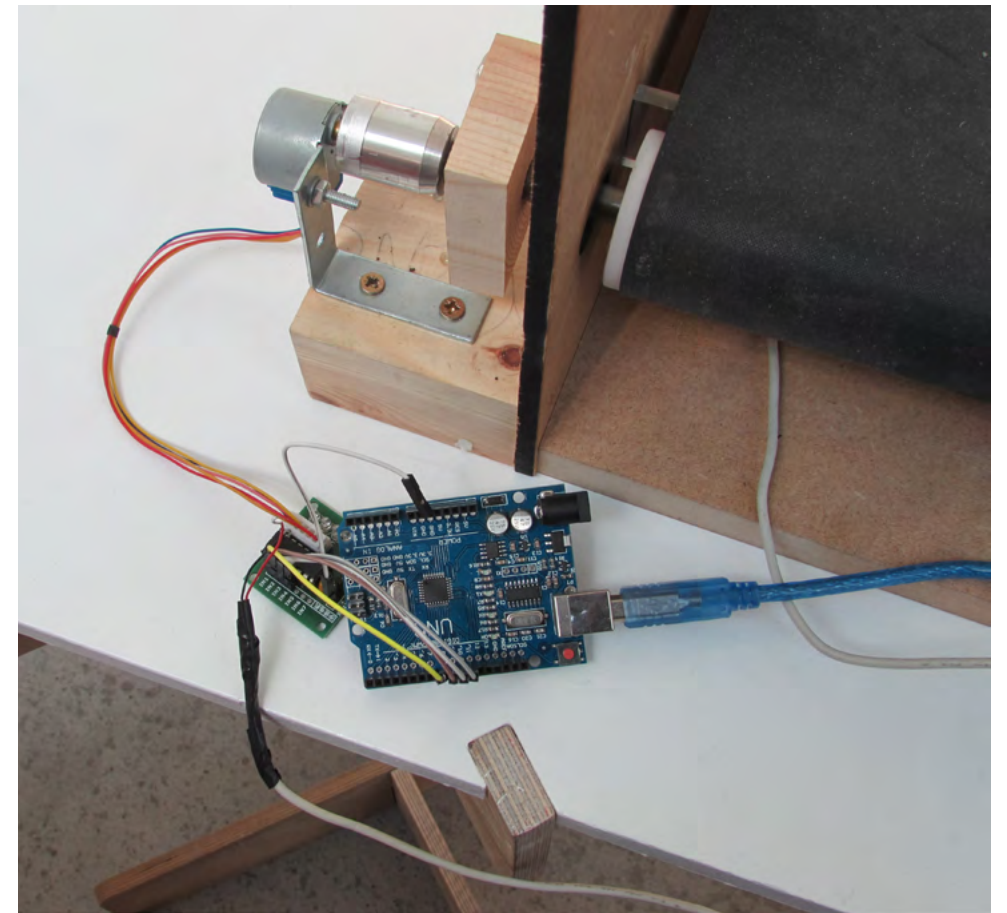
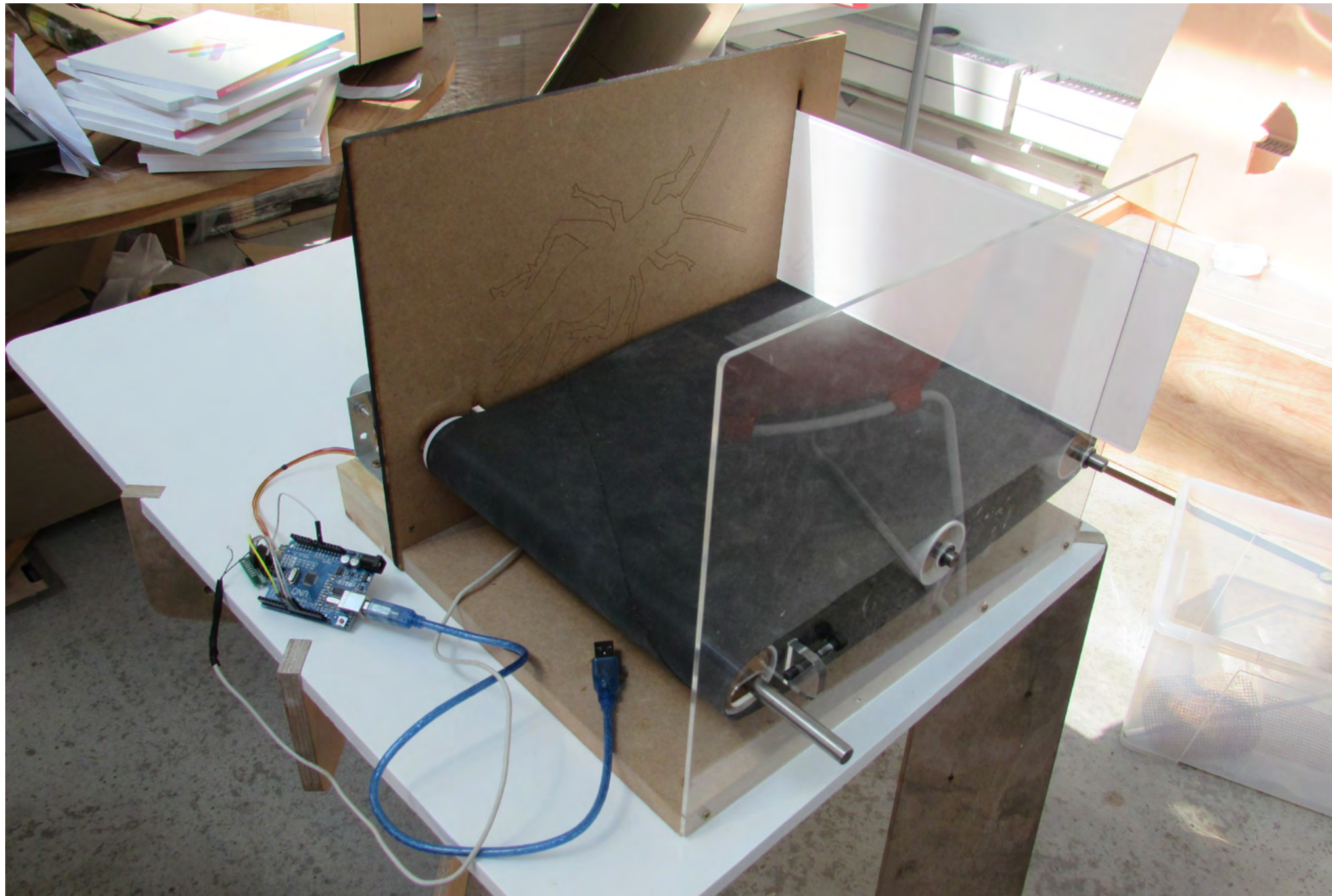
Example solution



Measure how much crickets are needed then close gate and...

Most commonly egg cartons are used to create surface area :) but I needed alternatives. Aluminium mesh seems like a good option. I thought about it halfway through, that's why it changes in the drawings above.





Perplex piece is movable to figure out what the bets tolerance is to get waste out while keeping crickets in!

Whole Crickets Vending Machine

What made things difficult is that I wanted to keep one big colony together and have constant numbers. This was never done and I had a lot of troubles figuring out what would be the best way to do it.

Crickets lay a lot of eggs - maths is complex ->

Trying to predict how many eggs should be left, how many crickets should be eaten to harvest 500g daily... 0.7 mortality.

Then Christmas happened. And some of the earlier user research hit me. Peer pressure! It was too ambitious of me to think that cool people will buy my machine and breed crickets in their kitchens. It was too early for this! Social context is needed! Education and Peer Pressure - the two most important research outcomes.

No more home appliance - vending machine time!

Cycle	Eggs	Mort	Teens	Adults	Adults weight	Weight eaten	Adults left
1	1000	0.7	700.00	700.00	350	341	18
2	1350	0.7	945.00	945.00	472.5	463	19
3	1425	0.7	997.50	997.50	498.75	489	19.5
4	1462.5	0.7	1,023.75	1,023.75	511.875	502	19.75
5	1481.25	0.7	1,036.87	1,036.87	518.4375	508	20.87499998
6	1565.62	0.7	1,095.94	1,095.94	547.9687496	538	19.93749911
7	1495.31	0.7	1,046.72	1,046.72	523.3593517	513	20.71870335
8	1553.90	0.7	1,087.73	1,087.73	543.8659628	534	19.73192563
9	1479.89	0.7	1,035.93	1,035.93	517.9630478	508	19.92609555
10	1494.45	0.7	1,046.12	1,046.12	523.0600082	513	20.12001643
11	1509.00	0.7	1,056.30	1,056.30	528.1504313	518	20.30086265
12	1522.56	0.7	1,065.80	1,065.80	532.8976446	523	19.7952892
13	1484.64	0.7	1,039.25	1,039.25	519.6263415	509	21.25268299
14	1593.95	0.7	1,115.77	1,115.77	557.8829284	453.366666	209.0325235
15	15677.4	0.7	10,974.21	10,974.21	5487.103742	440.666666	10092.87415

Something really important followed from this - I should not try to move crickets around to protect them from being eaten. Having a big vending machine meant that it might be much smarter to have separate cells keeping crickets from just one age. Not mixing ages.

Harvesting a whole sell when ready! Whoop whoop! no need to sort out anything!.. almost. :D



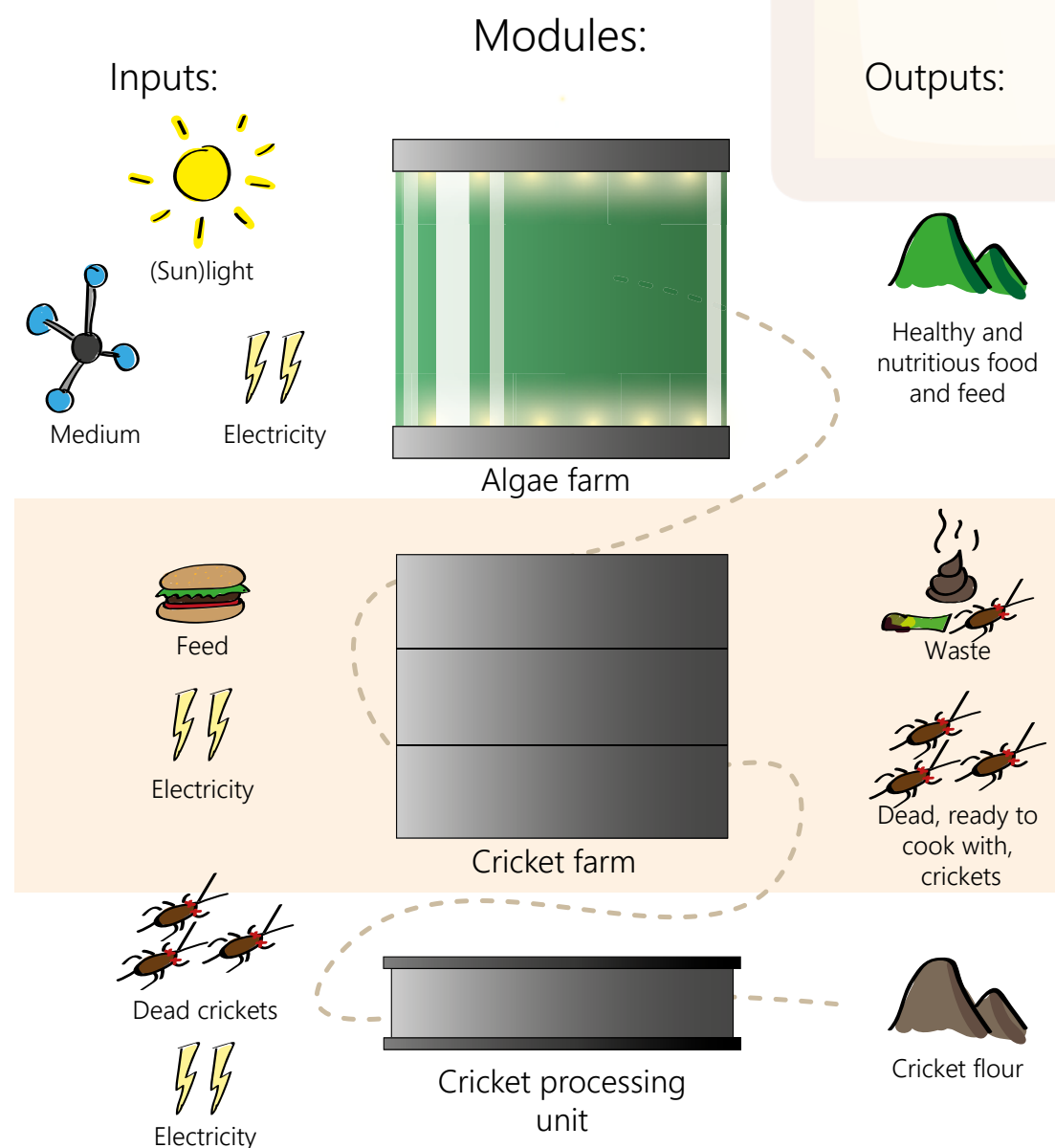
It turned out that educating people about the benefits of Entomophagy and letting them try it in social context are the two most important outcomes from user testing.

Getting vegetarian friends eat my home roasted crickets* made me decide on vending whole crickets.

Concept Development

Before:

- Algae farm to supply feed
- Cricket farm for breeding
- Processing unit - freeze drying crickets and turning them into flour

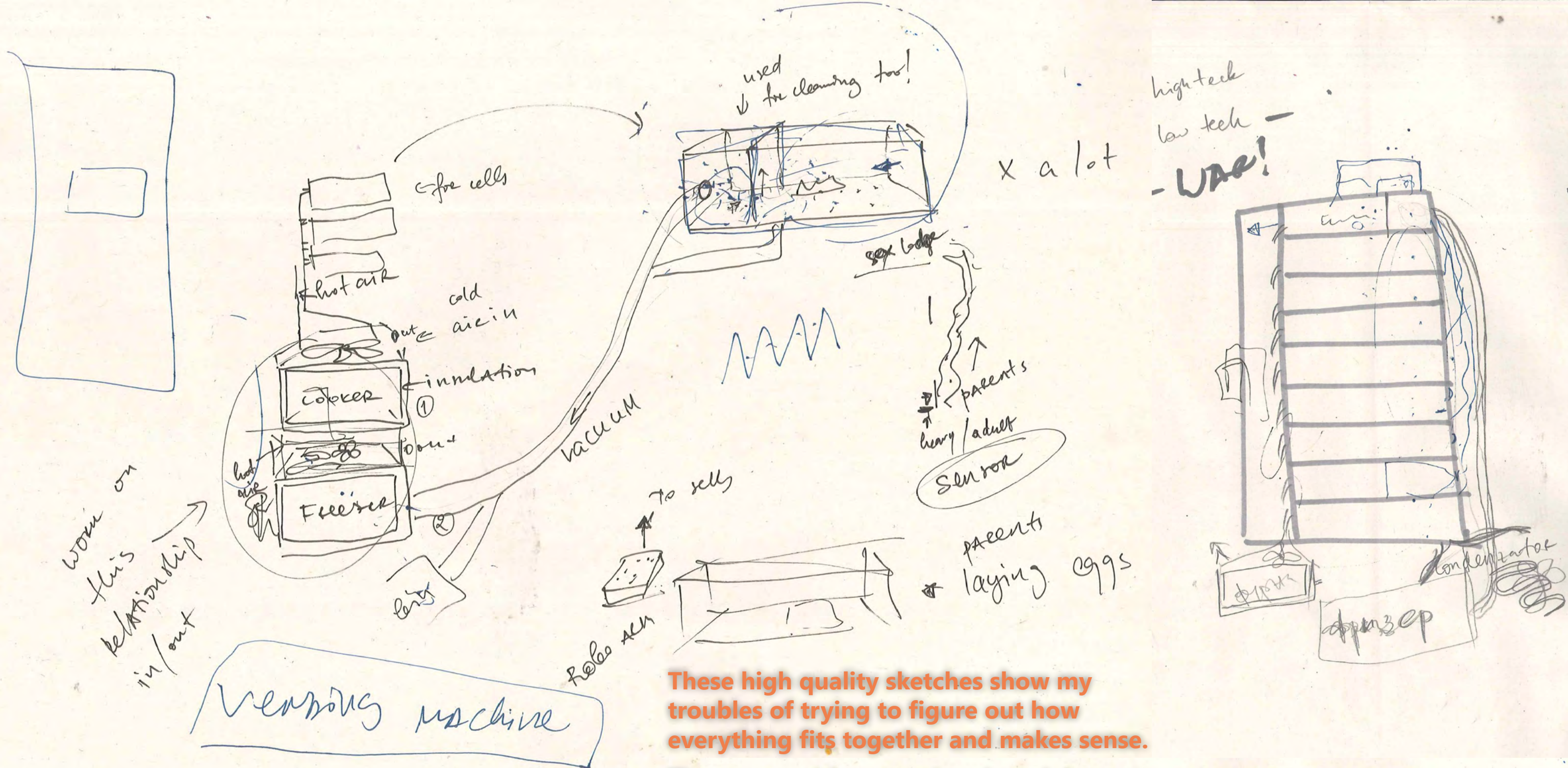


Now:

- Vending Machine/Coffee machine in public spaces - gyms, business buildings, supermarkets
- Bigger volume - more produce (numbers TBC)
- Stacking system - same module solving the life cycle of one generation repeated vertically
- No Algae Farm - Scope related - cannot solve two separate systems
- No freeze drying - too much energy consumption
- Baking unit
- Choice of crunchy crickets different flavourings - spicy, sweet, bbq etc.
- Could still have power bar/biscuit option - TBC (Need more cooking experimentation)

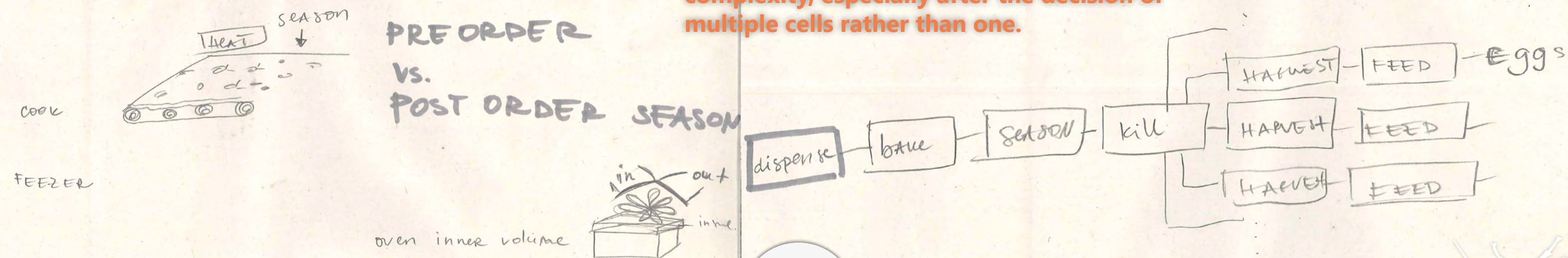


*Coffee machine picture taken from the internet and modified.



These high quality sketches show my troubles of trying to figure out how everything fits together and makes sense.

The conveyr idea was abandoned due to complexity, especially after the decision of multiple cells rather than one.



TUTORIAL 27.1.2017

Cricket dispenser → vending machine

next iteration - elements decided on & explained ish

ELEMENTS

① REARING modules



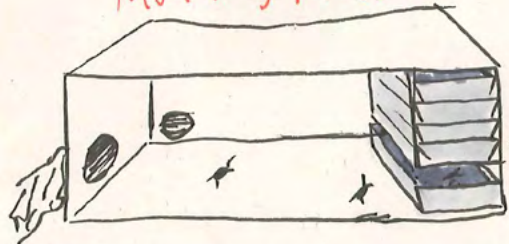
- ①.1 feed & WATER dry food
- ①.2 "Room 10L" - cleaning and kill vacuum
- ①.3 Main "hanging out" area
- ①.4 from ①.3 to ①.2 door

MOVING

Cricket prototype

- temp
- slope + drain
- food

② "Sex lodge" mating module



- ②.1 egg laying trays

- water
- GAS - no

Cricket scenario

Chicken run

CRICKET SPACE

required for 1kg per day 1.7 m³

one module

40 litre with furniture - 2000 crickets with furniture every 6 weeks

example volume output per day: 1kg = 2000 crickets (0.5g adult)

42 modules x 40 litre = 1680 = 1.68 m³ of cricket area

1 female up to 100 a day 50%-60% hatch

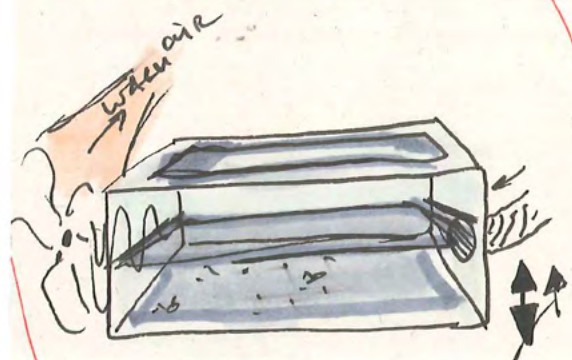
⇒ $\frac{2100}{55}$ (2000 + 10% mortality) = 38.2 → 40 females + 40 males

SAY 100?

MORE SPACE = MORE SEX ⇒ give them 20 litres = 0.02 m³

oops! Insulation

③ FREEZER



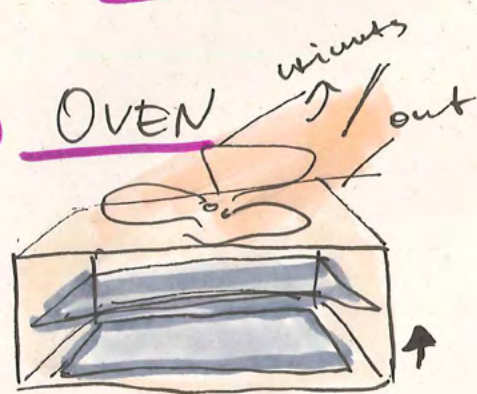
tray shakes & ...

let's say cricket density = 1 :)
1kg = 1litre - But in case it's better to have more.
But not too much more, CAUSE ENERGY
5L freezer? + **check legitimacy**
+ 2L-fan system + compressor

just cover

kill

④ OVEN



7-2L
+ fan

⑤ "3 circles of hell" - connects oven & FREEZER

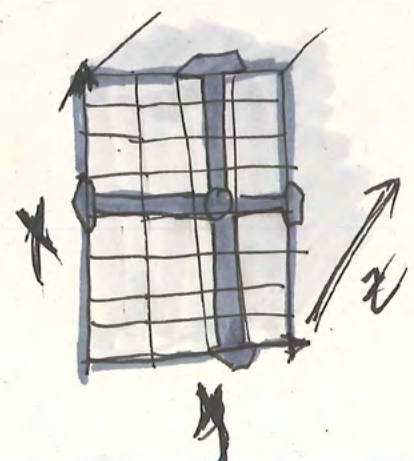
no freezer



Bottom opens → tray in mid space →
→ bottom door shuts → oven door opens →
→ crickets cooking

⑥ + Cartesian Robo ARM

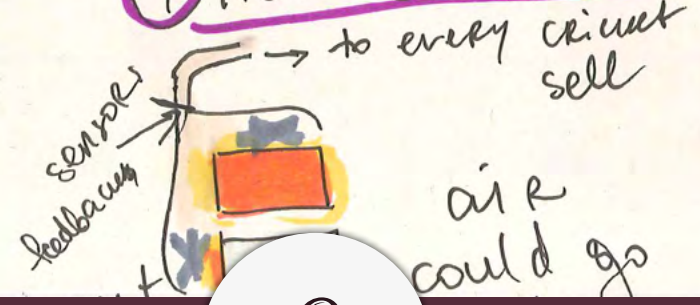
* egg trays from "Sex lodge"
to cells



⑦ Bin

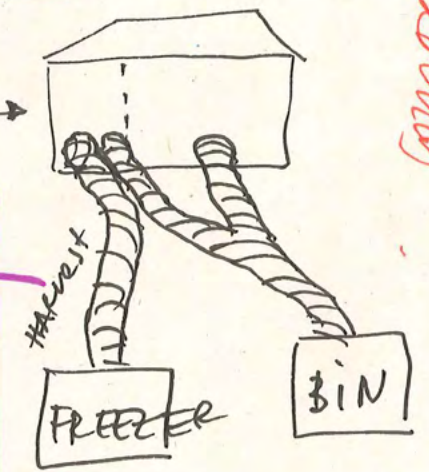


⑨ Heating/cooling



⑧ Vacuum system

every single
① Breeding module →



compressed air

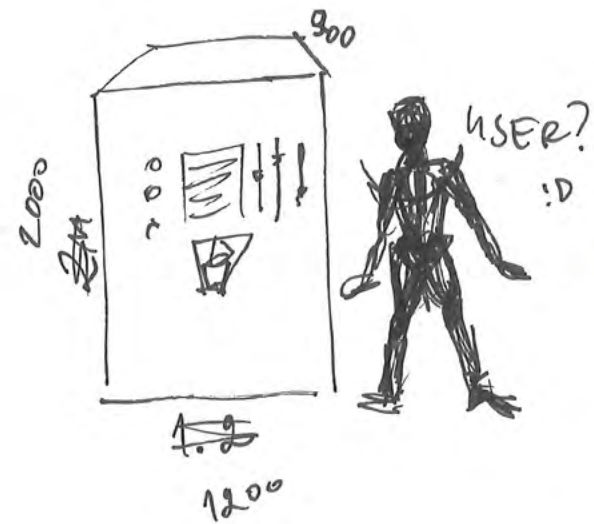
⑩ DISPENSING

OVEN → USER
SEA SAVING;
cup dispenser.

USER JOURNEY

Tutorial 27.1.2017

Example layout



SWEET

SPICY

SALTY

GREASY

20g

35g

50g

100g

WARM
COLD

pay



2 min

optional lid



USER

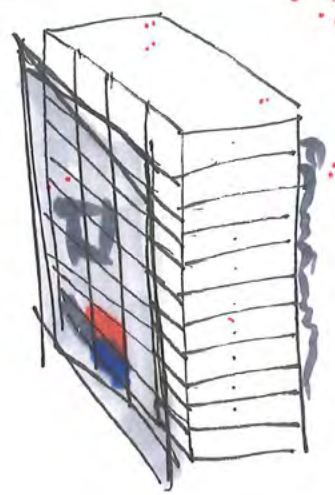


HAPPY

earth



~~Better CAD it...~~

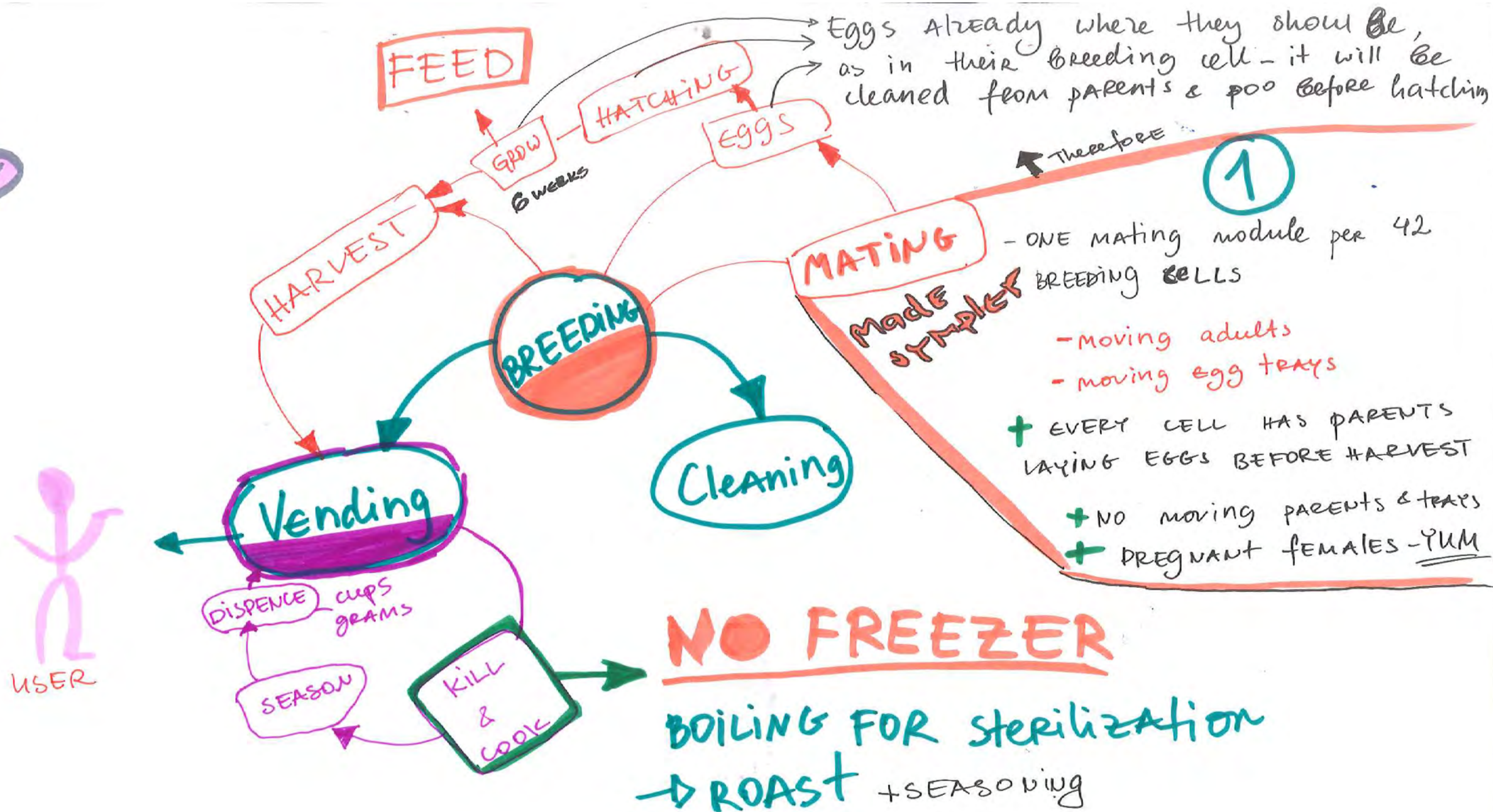


~ 2m³

User Journey

10.2.2017

SIMPLIFY DATA



- | For example, Miles Olson recommends frying, roasting, toasting, suffocating, or drowning crickets

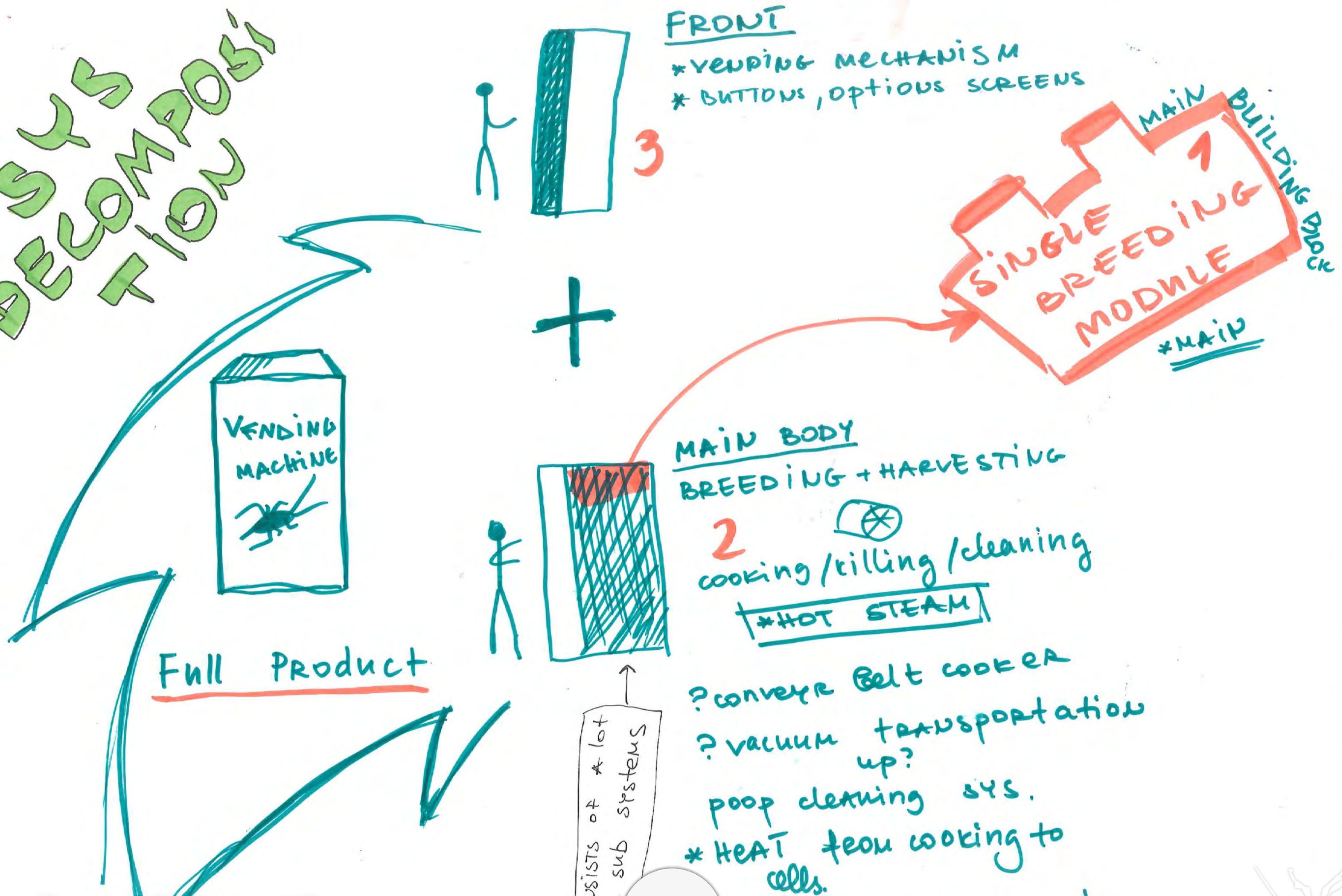
Insects destined for human consumption are first sterilized in hot water and then are refrigerated or freeze-dried.^[6]

Cricket: eaten fried, sauteed, boiled, and roasted, these are amongst the most common insects eaten. Eaten in Mexico, Thailand, Cambodia.

<https://edibug.wordpress.com/list-of-edible-insects/> - comments are cool - use for docs

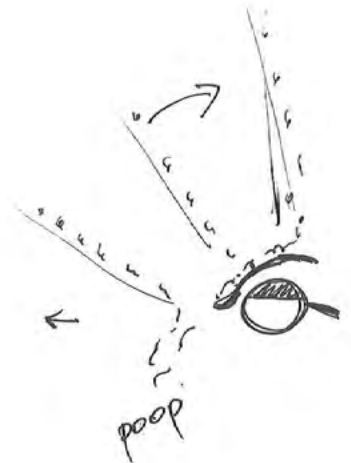
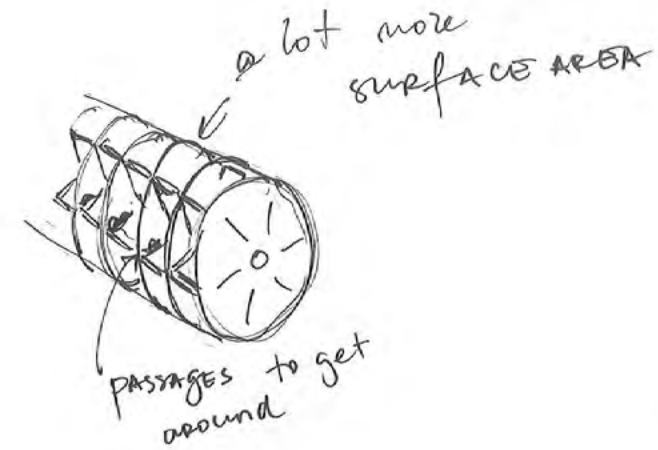
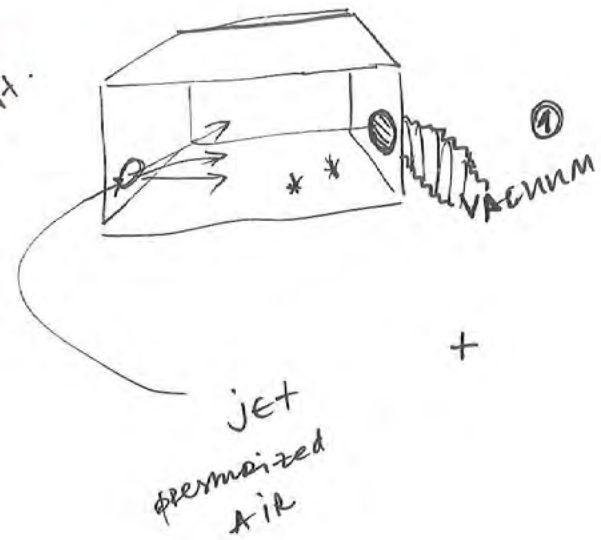
https://en.wikipedia.org/wiki/Welfare_of_farmed_insects

System Decomposition

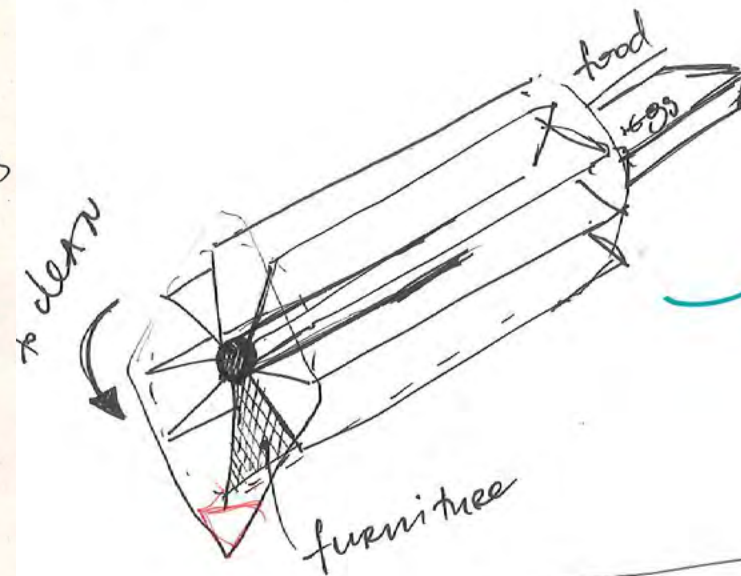


HARVEST → MOVE them from ONE place to another (freezer, oven, microwave) 10.2.2017

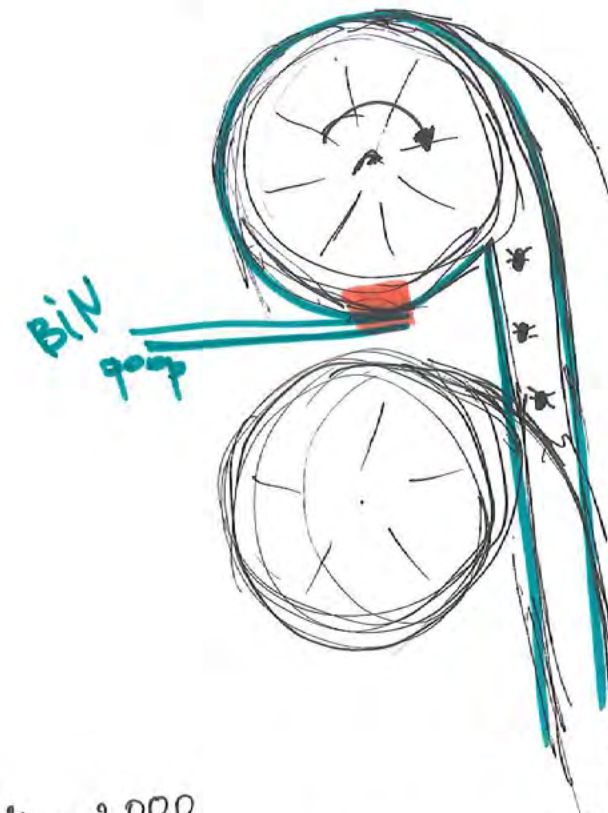
if furniture?
What happens to it.



"TURBINE BUILT"



harvest with centrifugal



centrifugal forces harvesting
SPACE EFFICIENT

$2.5 \text{ m}^2 \text{ min}$
 $3 \text{ cm}^2 \rightarrow 4 \text{ cm}^2 \times 2000$
 8000 cm^2 per all

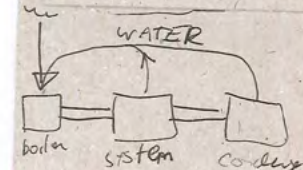
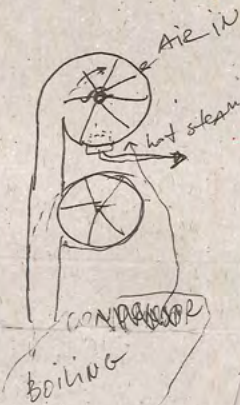
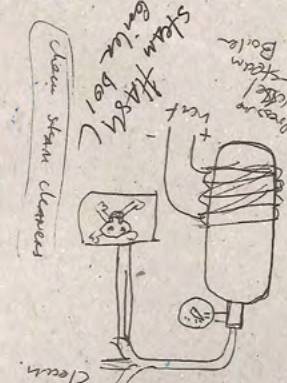
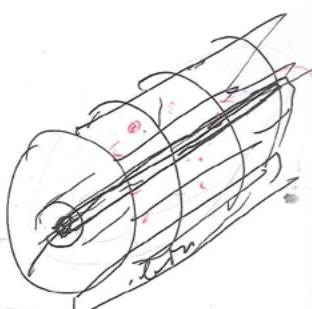
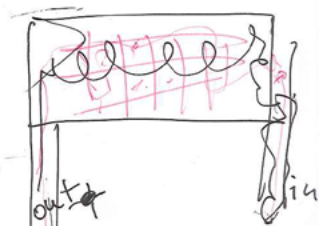
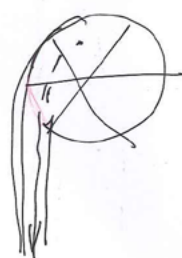
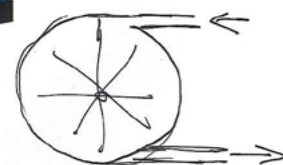
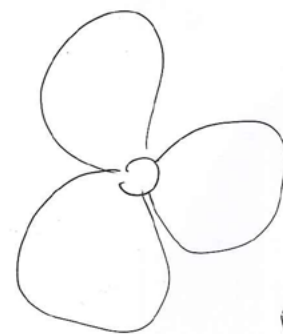
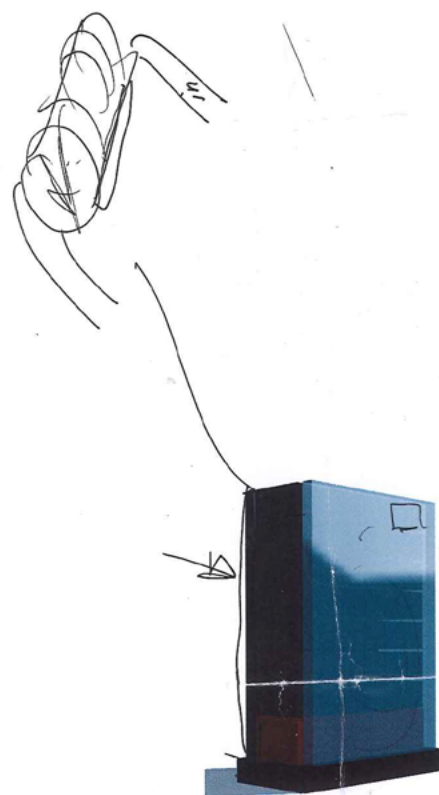
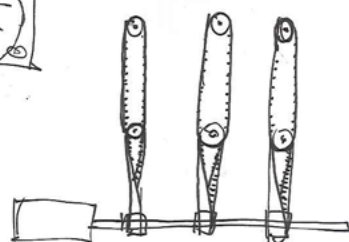
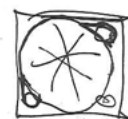
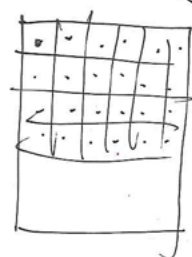
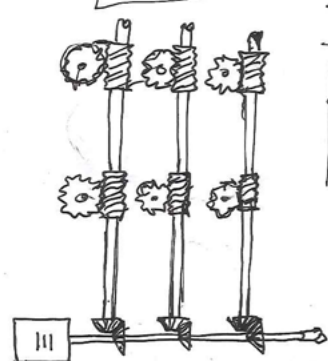
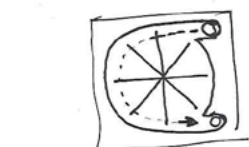
section surface AREA
 r, l, h
example $r=15, l=2, h=13$
 $= 1829 \times 5 \pi r^2$
 9149
 $2 \times \bigcirc$
 $+ 16 \times \square$
or 20

Swatches
Crickup
Cubcup

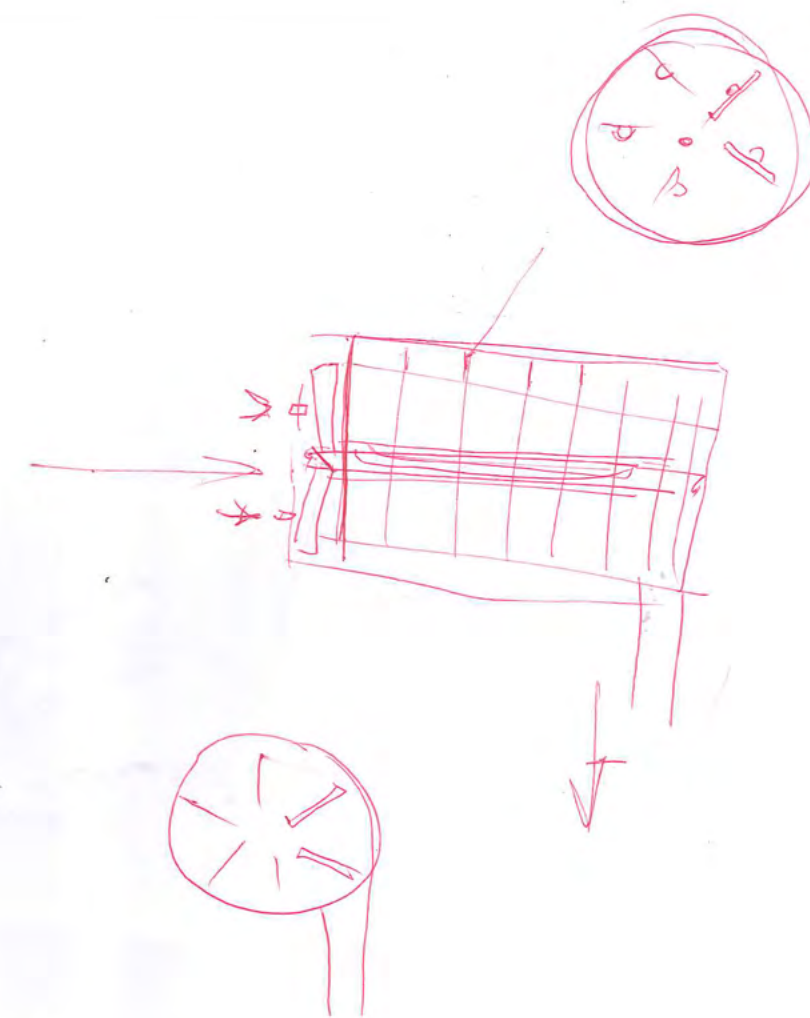
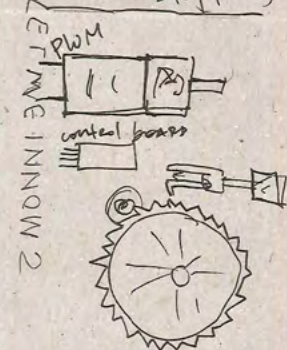
big de



Unidirectional
clutch

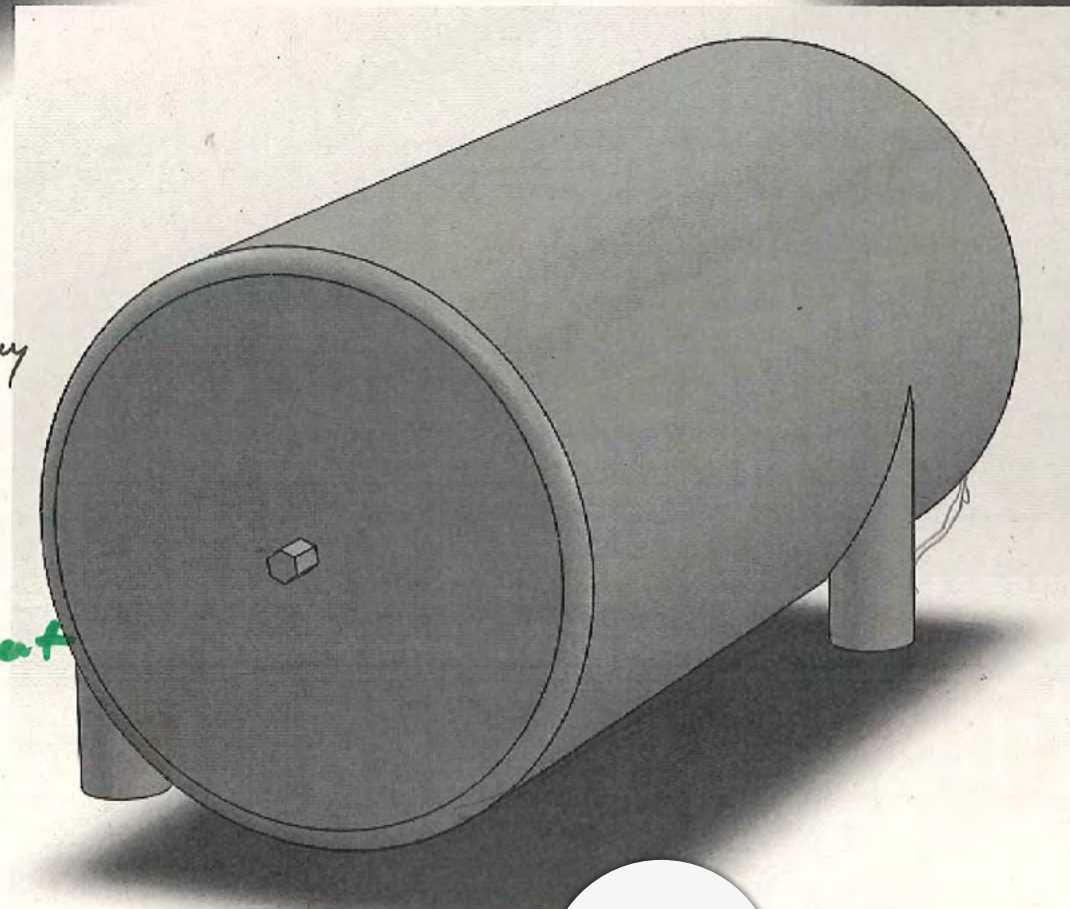
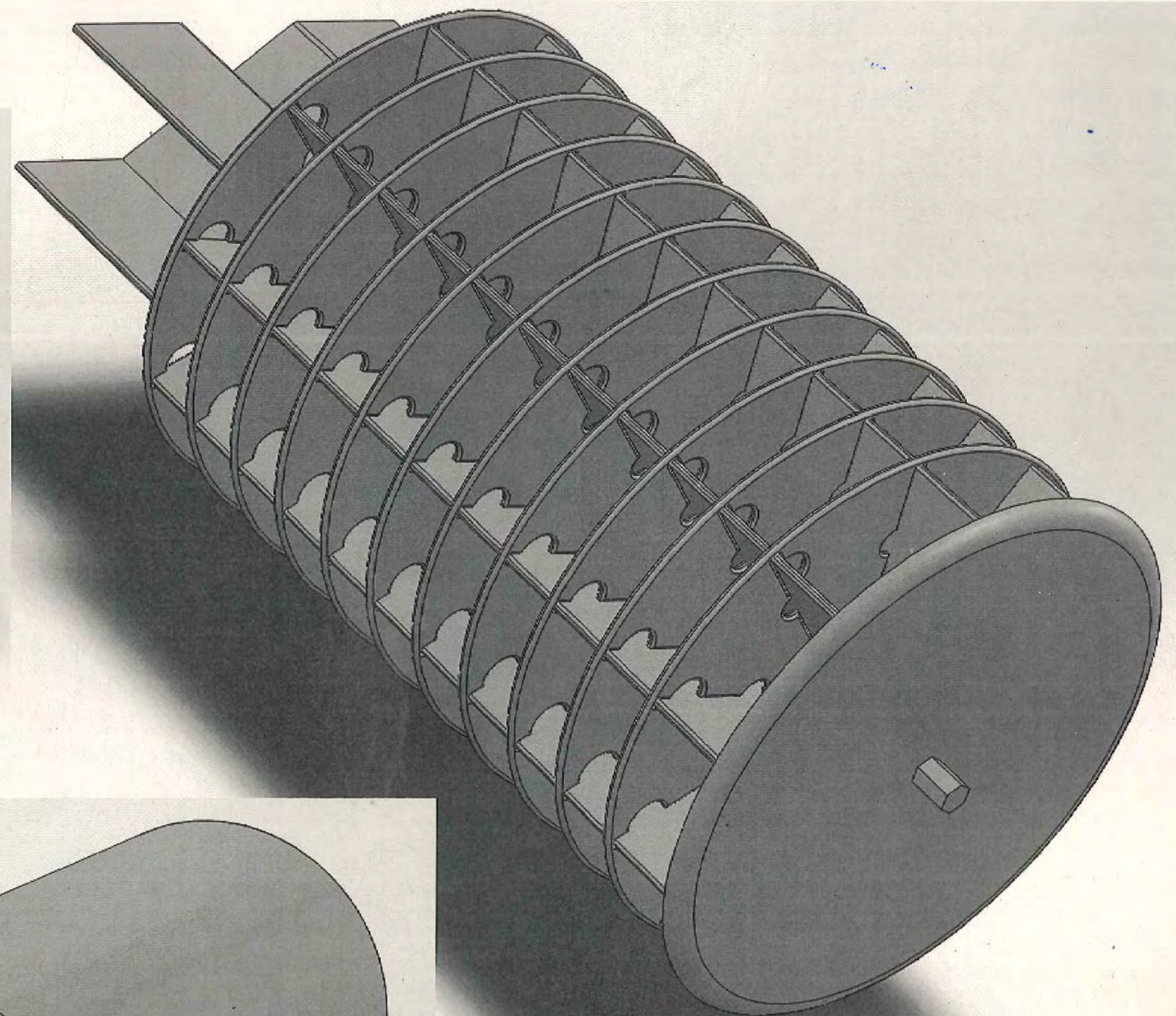
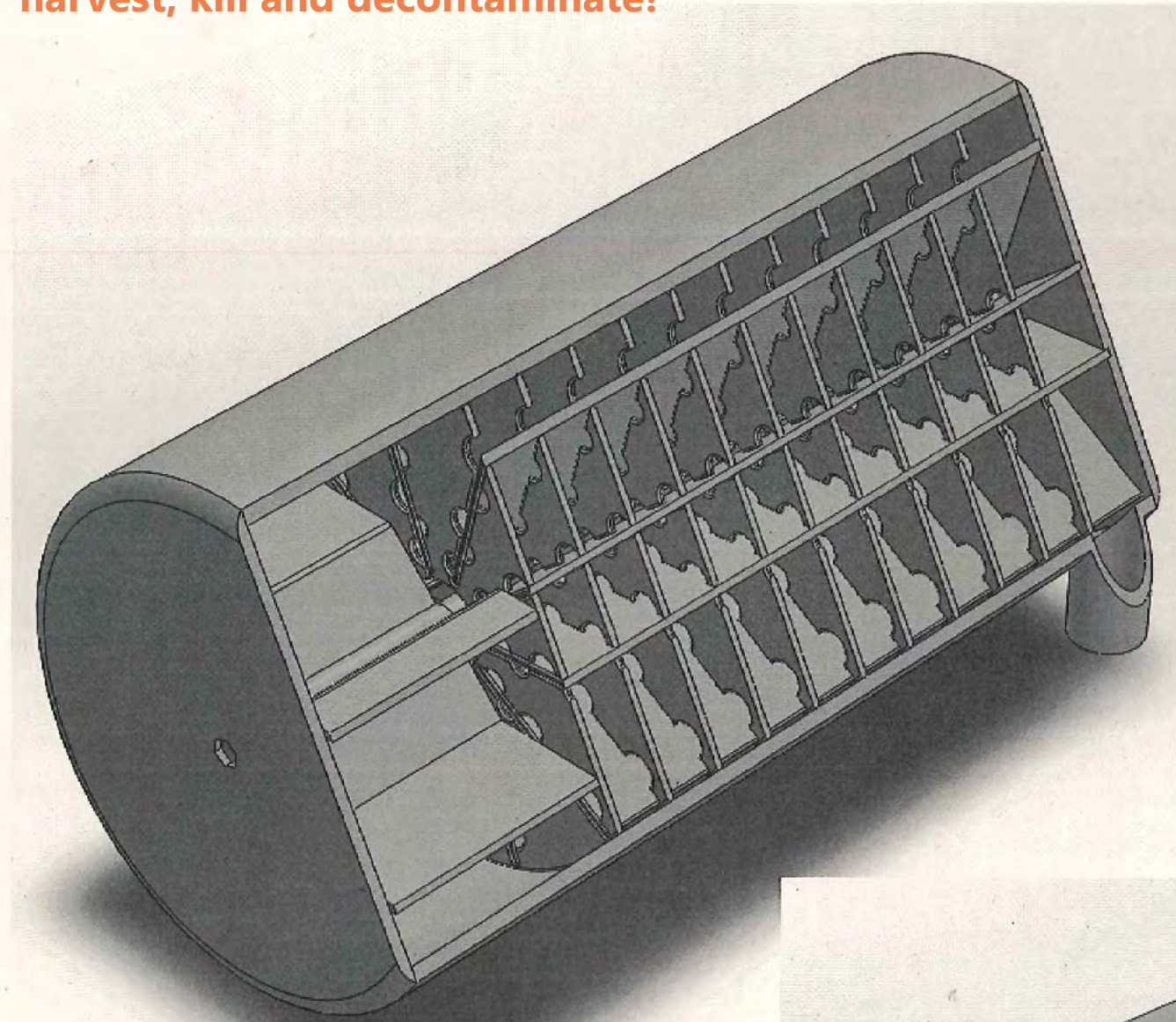


42 better
than 1
gear? than
stepper?



Providing a record breaking surface area per volume together with it's rotation - getting rid of waste, this was definitely a break thorough in my design. No more moving crickets from one place to another. Centrifugal forces can be used to harvest! Cricket wouldn't mind slow constant rotation :)

Another important moment came when I decided to use hot steam to harvest, kill and decontaminate!



PRESI PLANN *flavour* log a day

① Visualisation explanation

② Insides + explanations

③ User JOURNEY

④ To do's.

HUMAN → Curious

Watch Dragon's de pitches

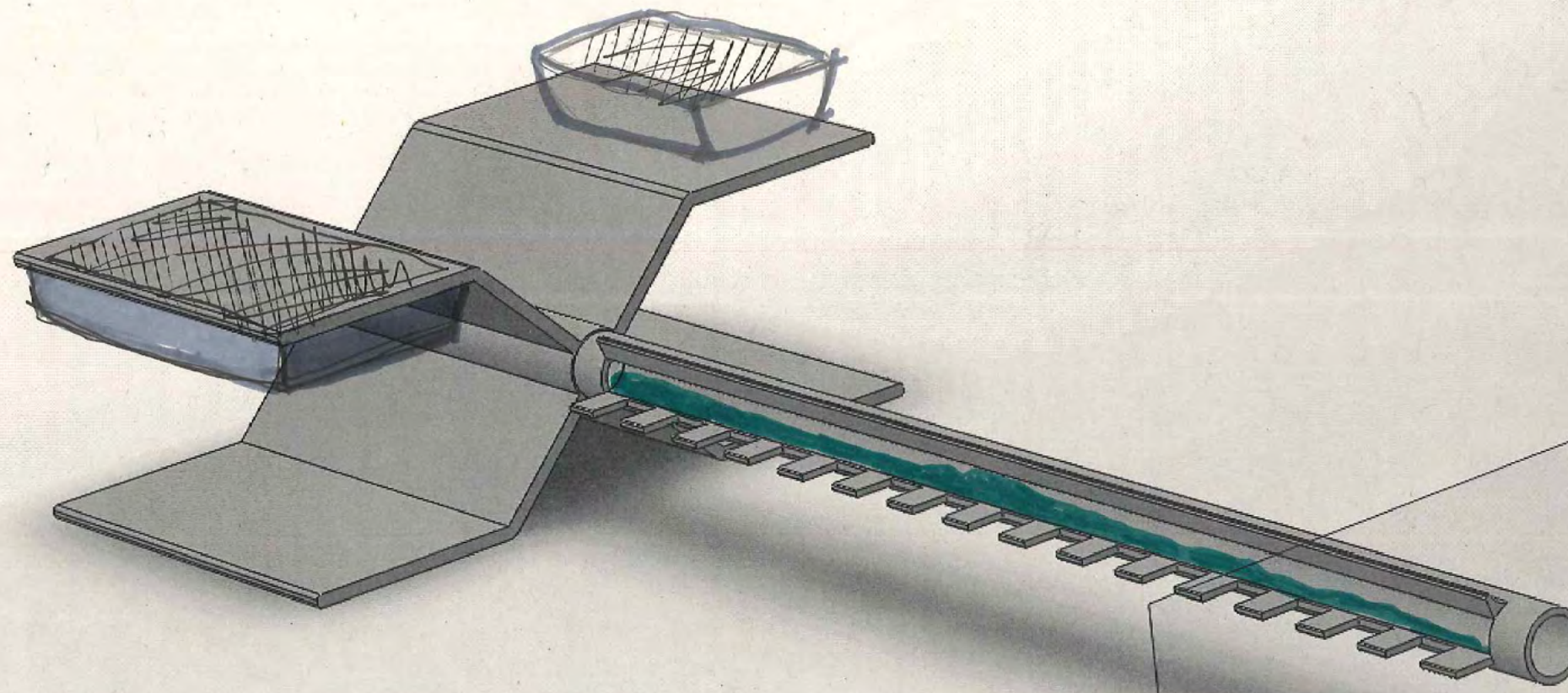
TURBINE inlet /outlet?
TEST RADIAL vs. AXIAL

STEAM FLOW



Steam works!





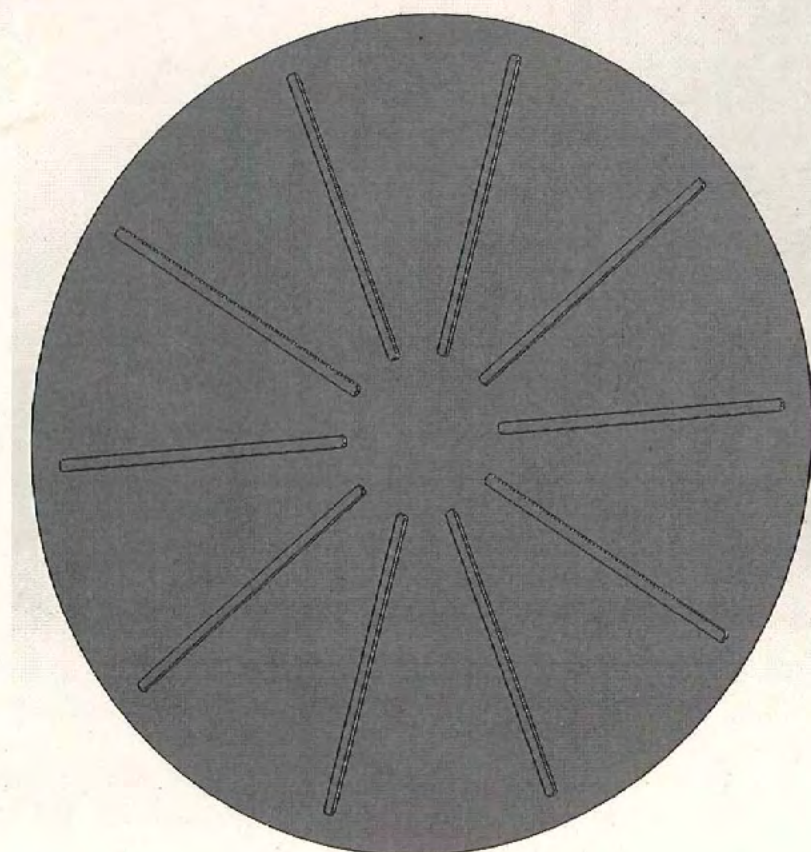
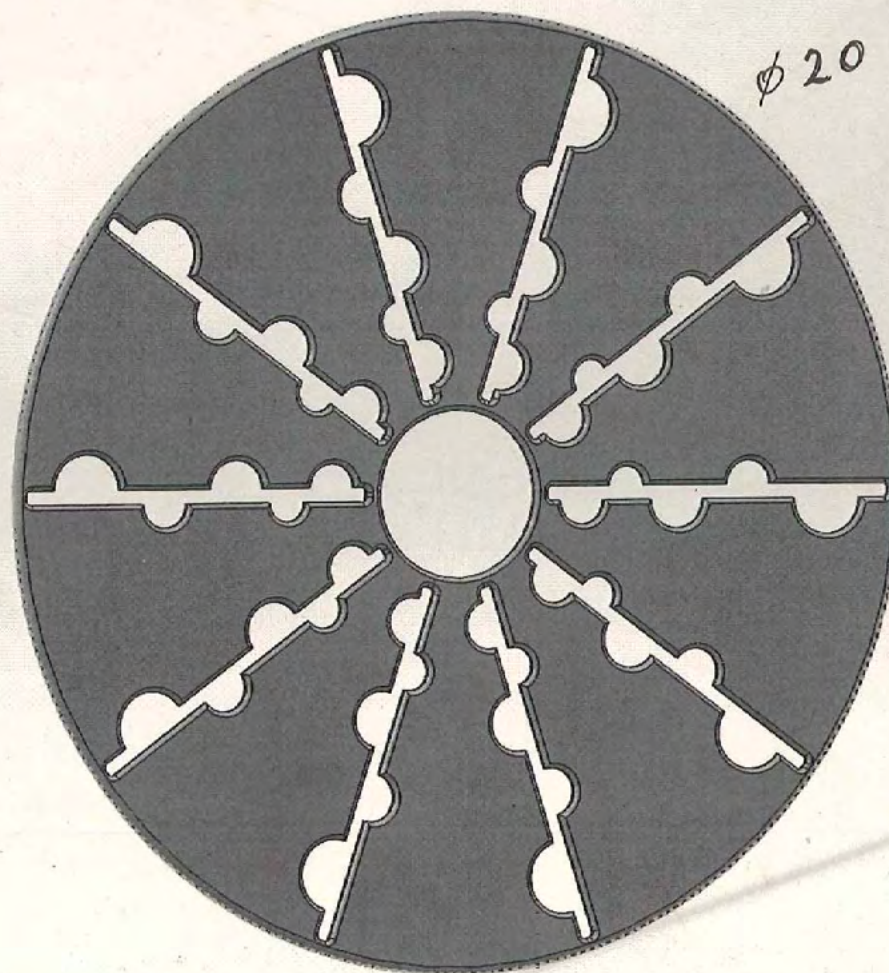
Surface Area

File Edit View Insert Format Data Tools Add-ons Help All changes

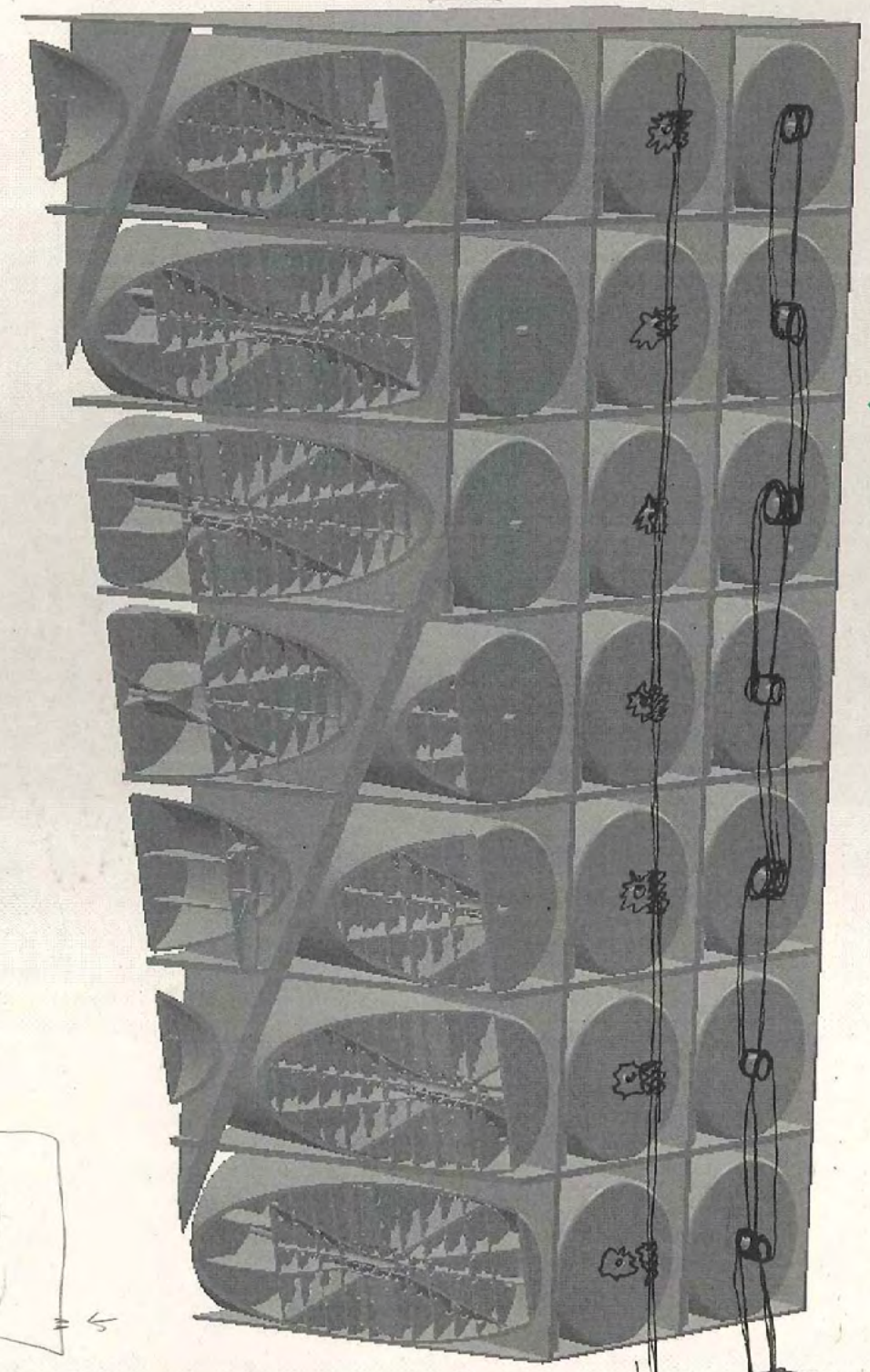
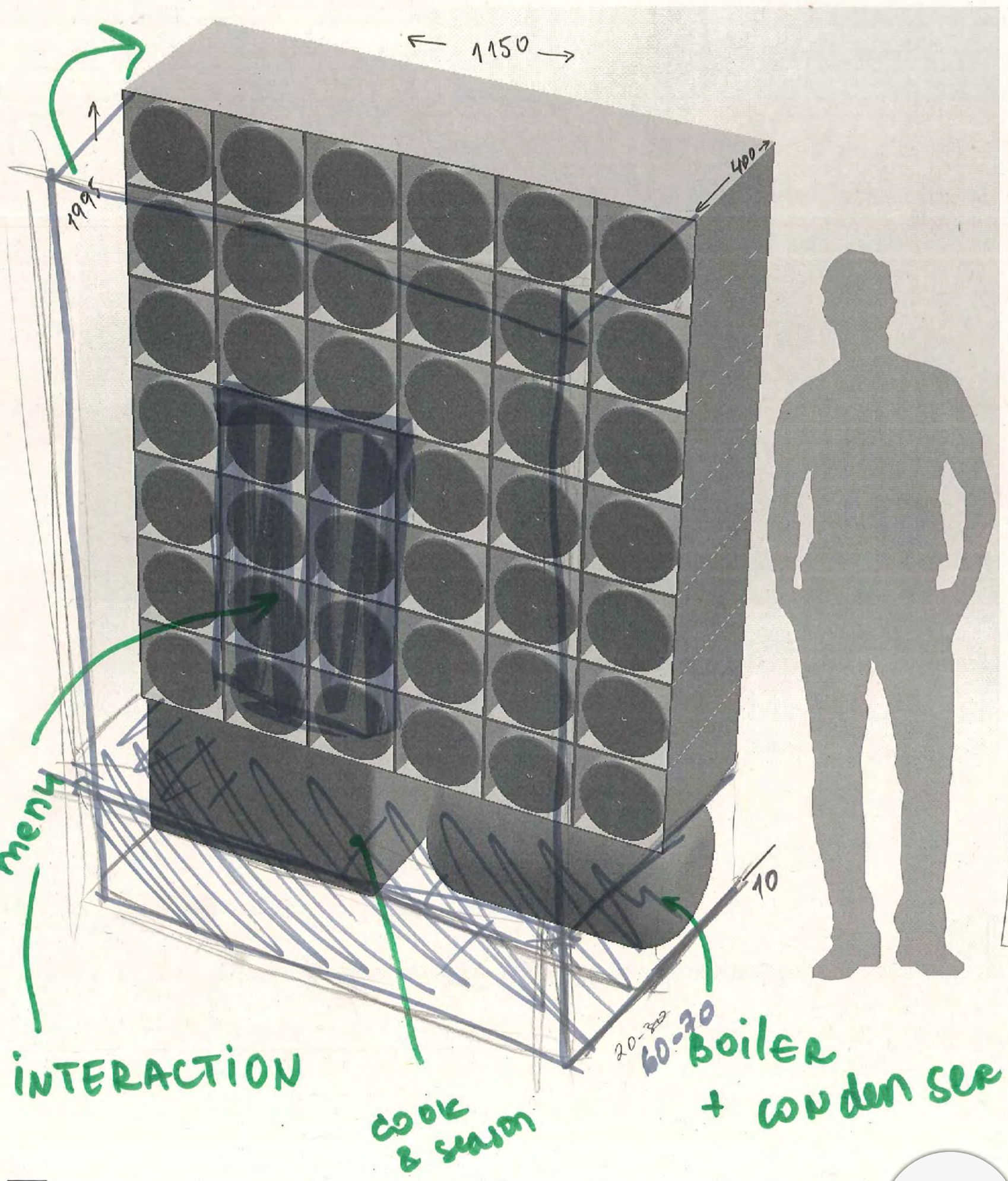
£ % 0.00 123 Arial 10 B I

fx =B17*B16

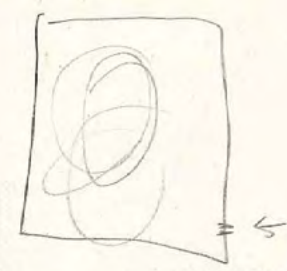
	A	B
1	Variables	
2	Total length calculations:	
3	Length of square plates	28.86
4	Number of square plates	10
5	Height of square plates	8
6	total surface of square plates = cm2	4617.6
7	Radius	10
8	Number of circular plates	10
9	Total surface of circular plates	6283.185307
10		
11	Volume=2xarea of circular plates + 2 times area of square plates	10900.78531
12	square dimensions of cell	20
13		28.86
14	Section calculations:	
15	Length between circle plates	2.6
16	Number of sections	10
17	Surface area per section	836.3185307
18	Rough length	28.86
19	Total area	8363.185307
20		



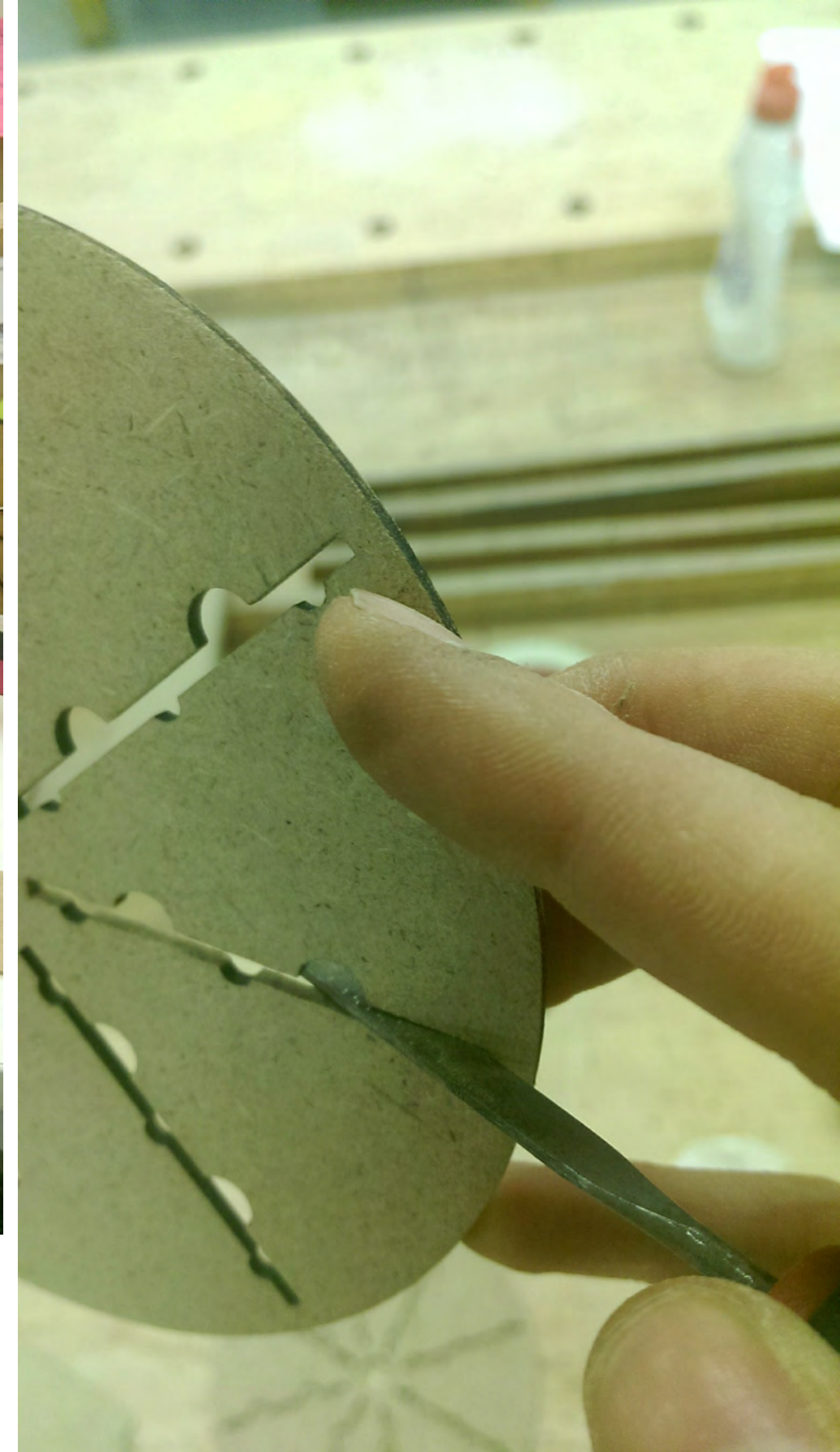
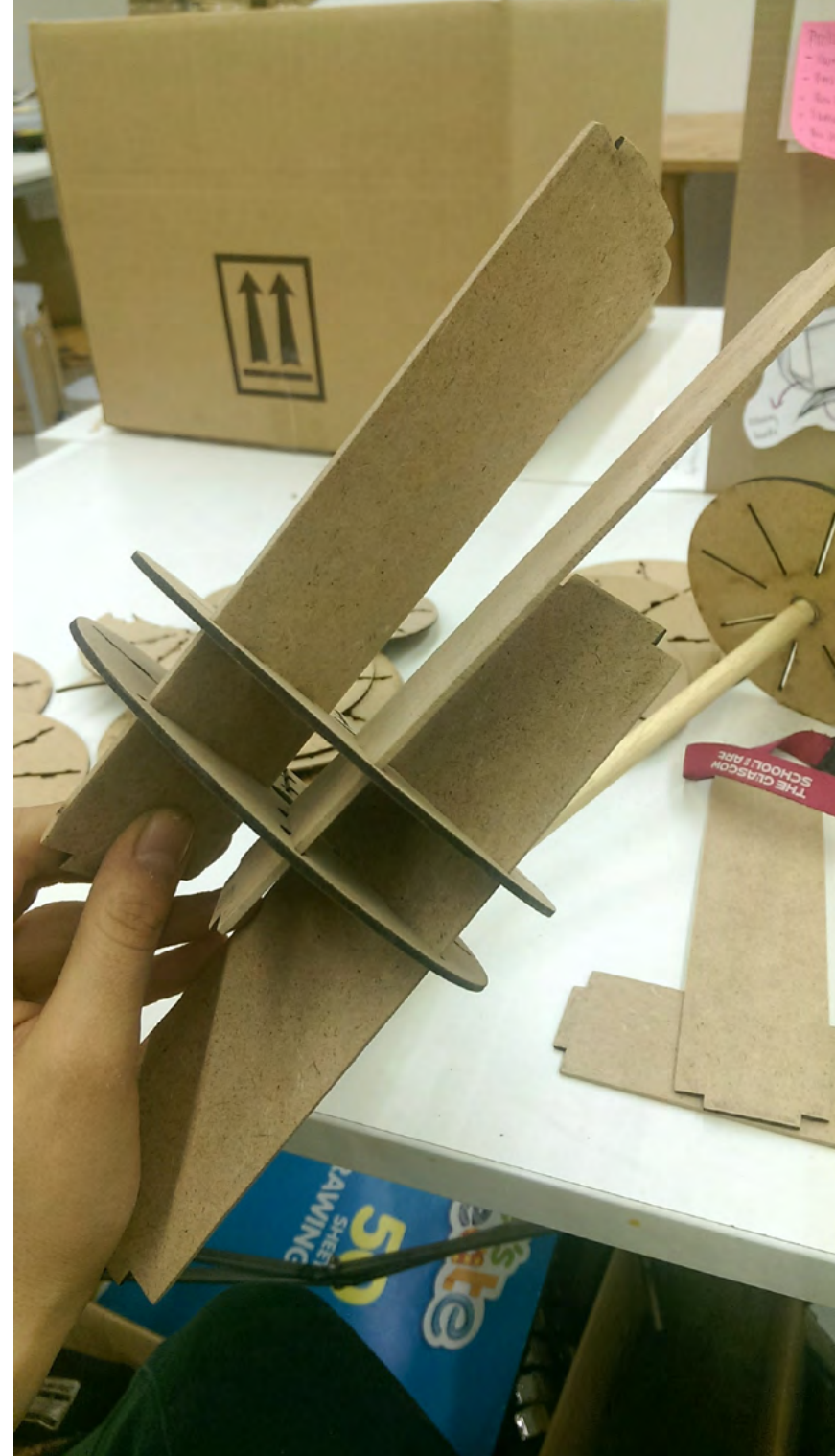
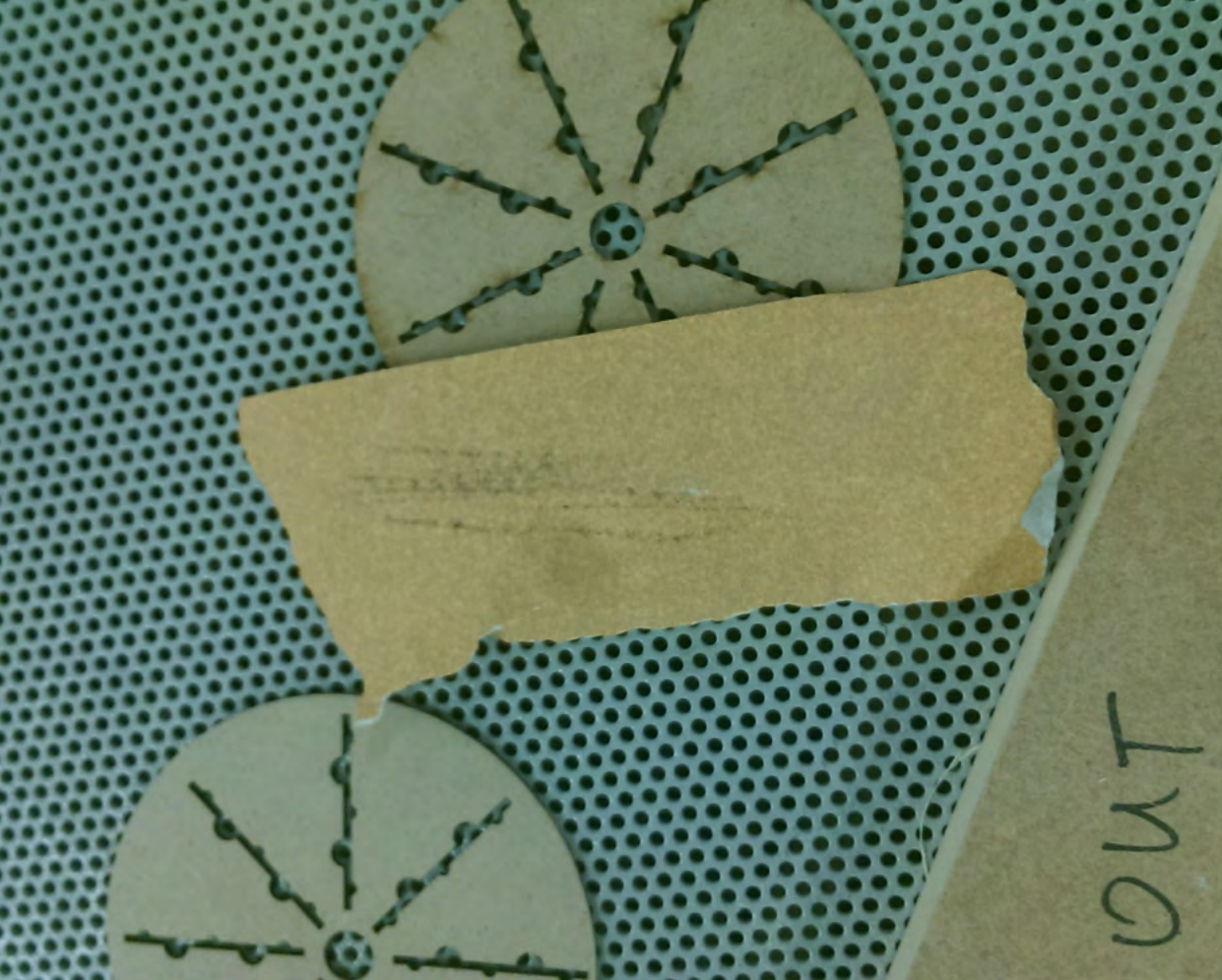
SCOPE!



+ unidirectional clutch



1 motor → 42 ?

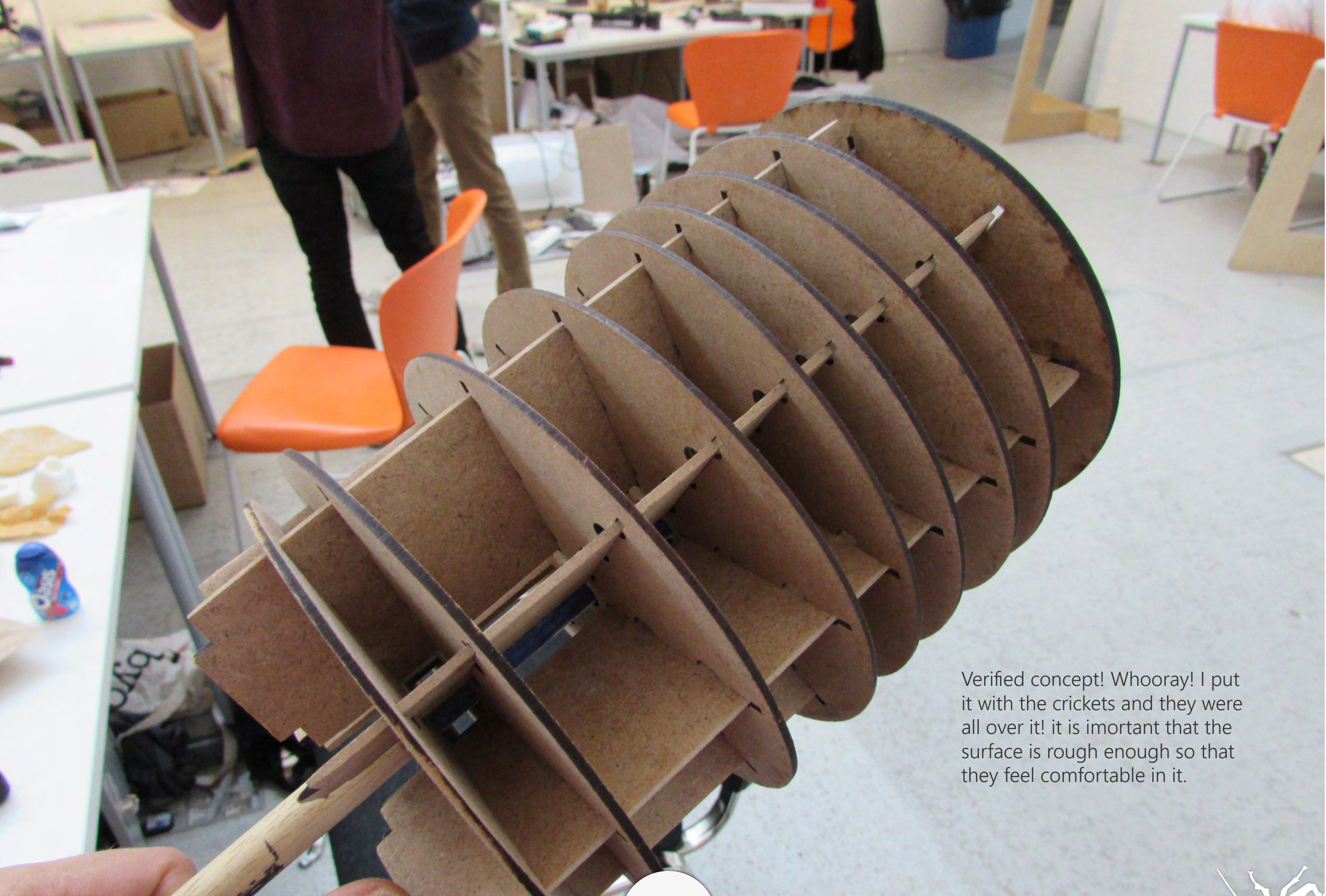


It was ridiculously annoying to assemble it. That MDF and darn friction :D

After some sanding and swearing I had a working prototype!

Using a bearing I made the rod stay still while the living area (circles and squares with holes for the crickets to roam around happily) rotates.

Food is in the middle!



Verified concept! Whooray! I put it with the crickets and they were all over it! it is important that the surface is rough enough so that they feel comfortable in it.

From Pre-submission presentation



1.12m²
1kg of crickets
a day



in context

Sports centres



Food hall



Supermarkets

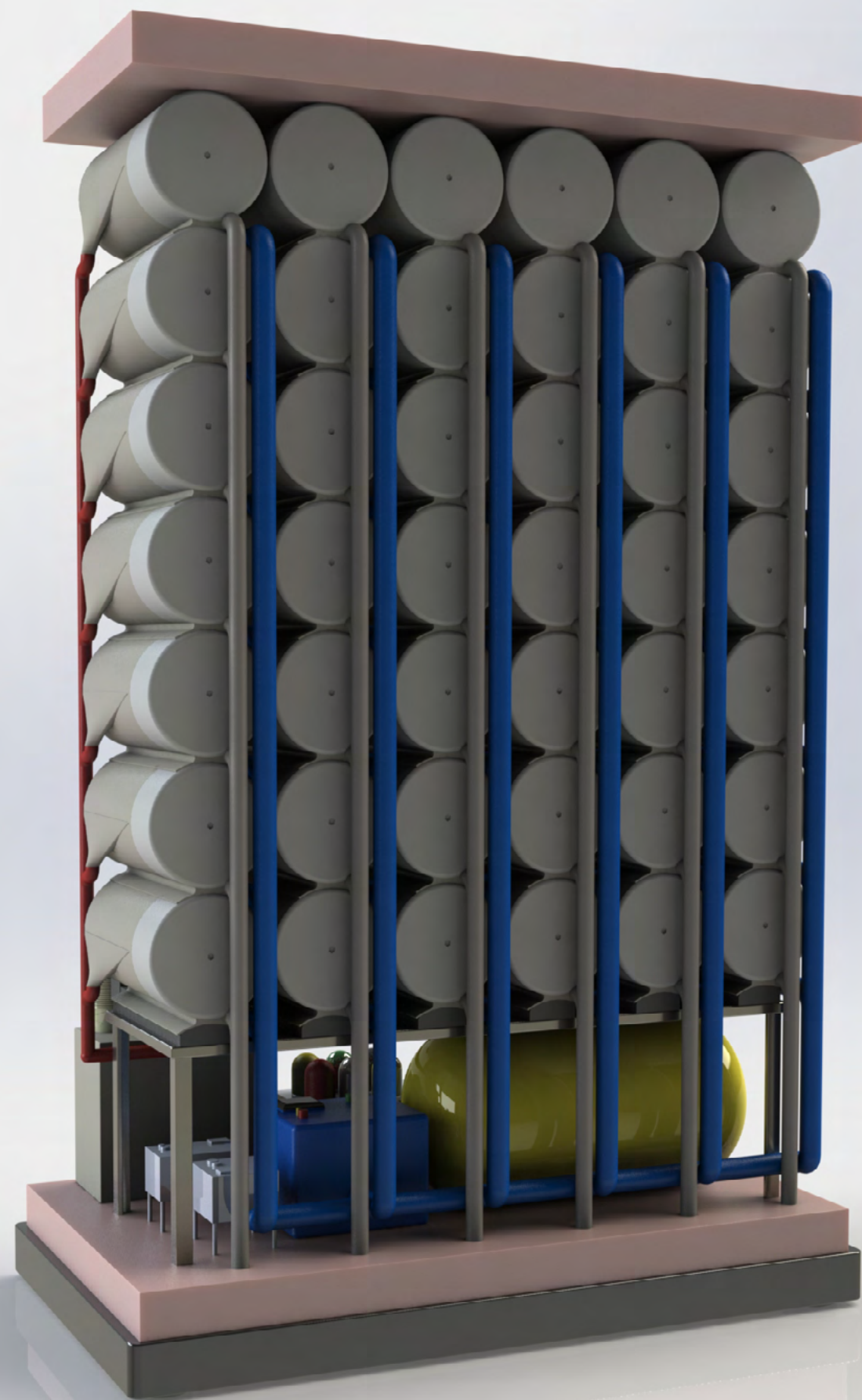
Offices

in context

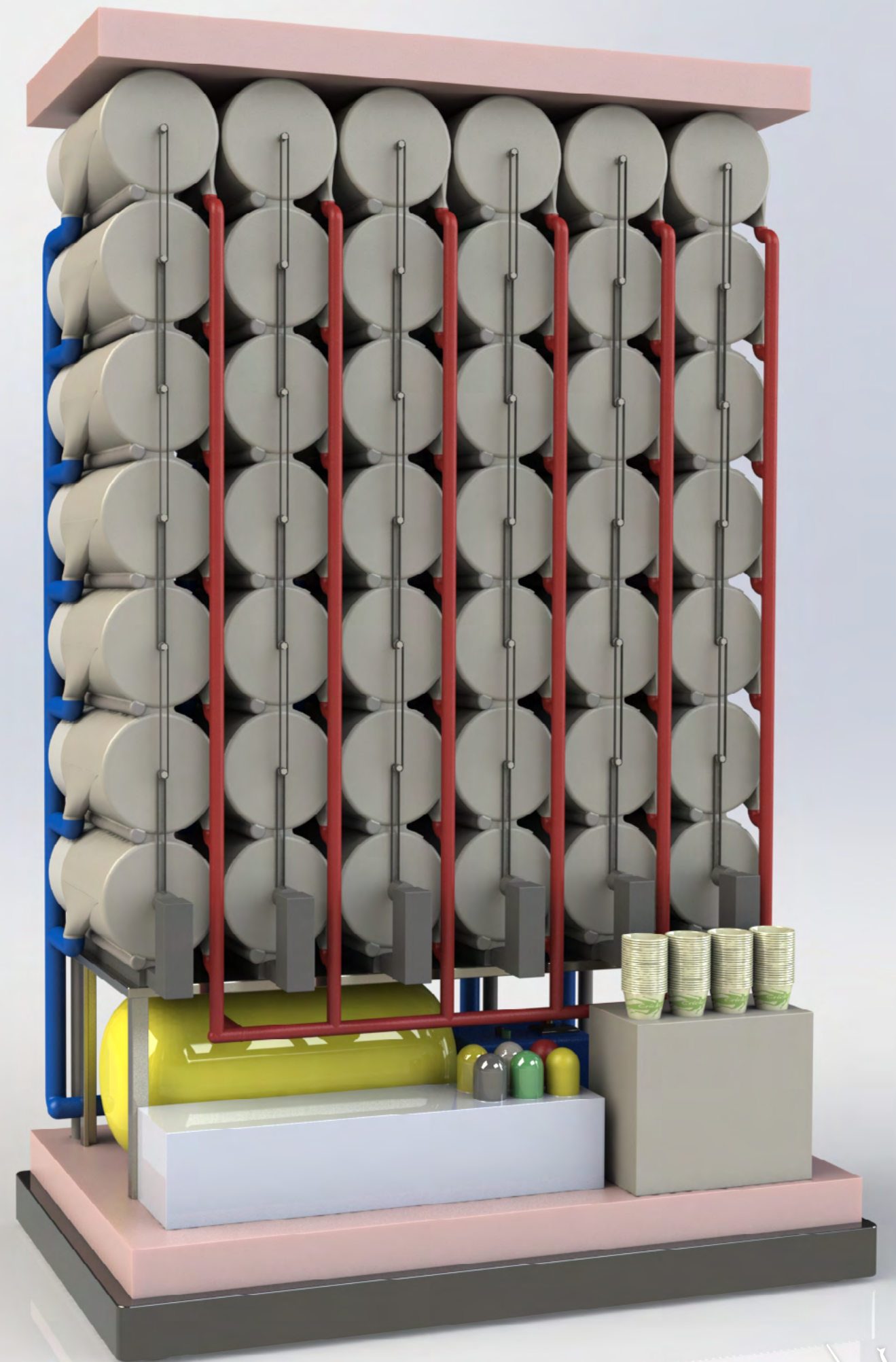


Hotels





Insides



Cooking unit

Boiler

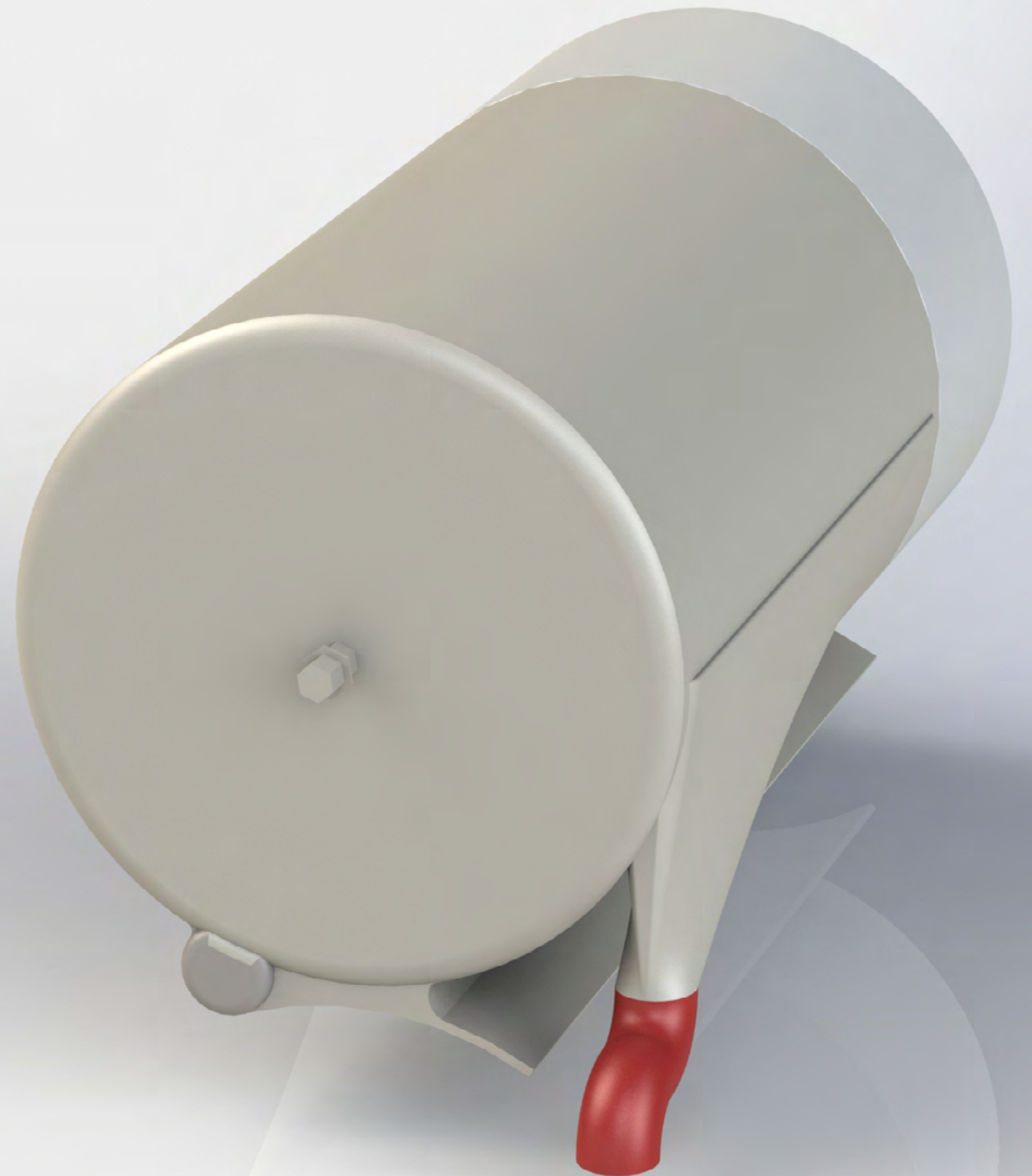
Condenser unit

Control unit

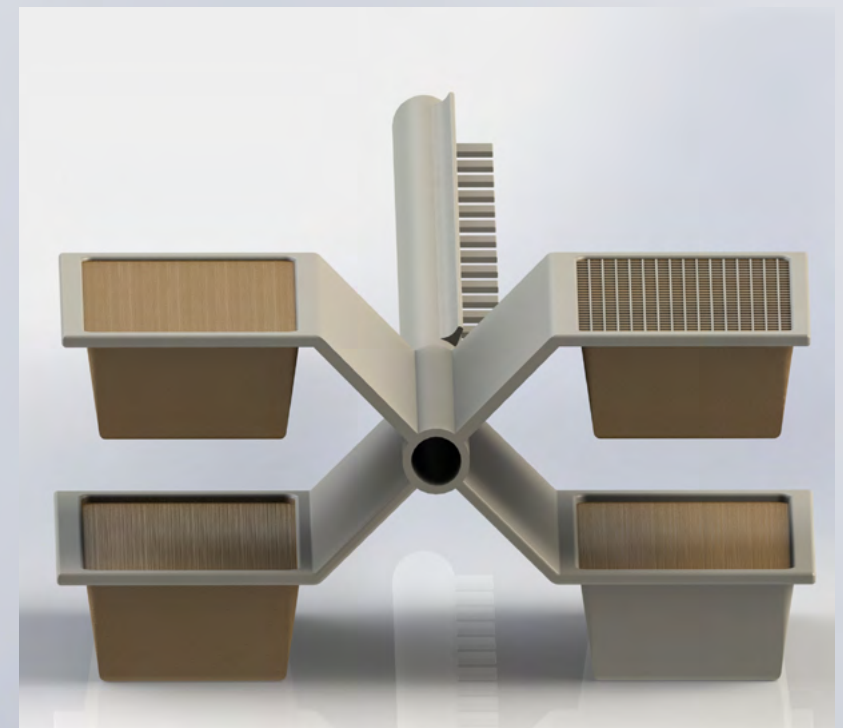
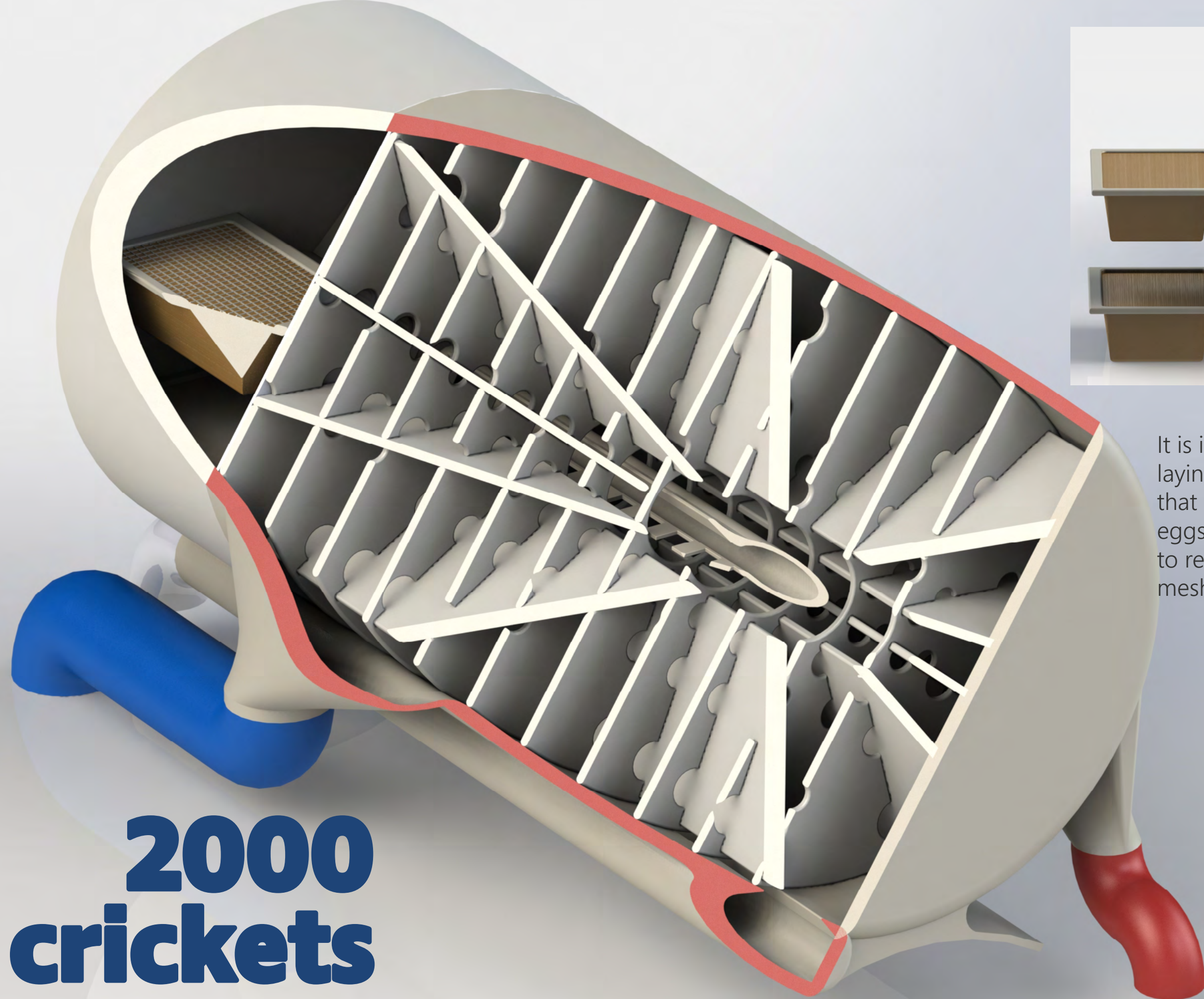
42 elements, each of them
having 2000 crickets on
each of days of their life
cycle :)
Harvesting one a day - 1kg



42x



Breeding unit

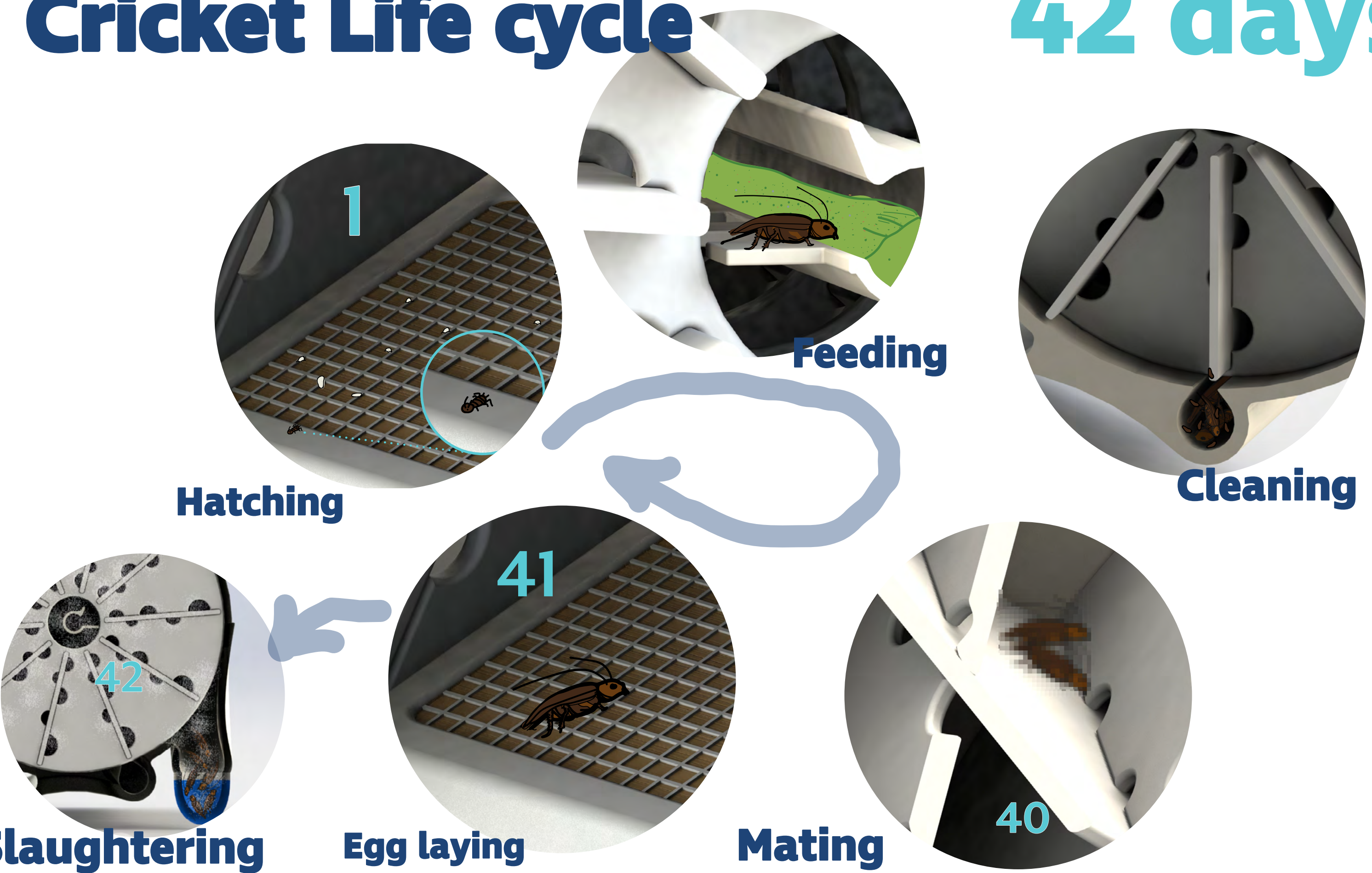


It is important that the egg laying trays are covered, so that the males don't eat the eggs. (Just one covered due to rendering difficulties of a mesh)

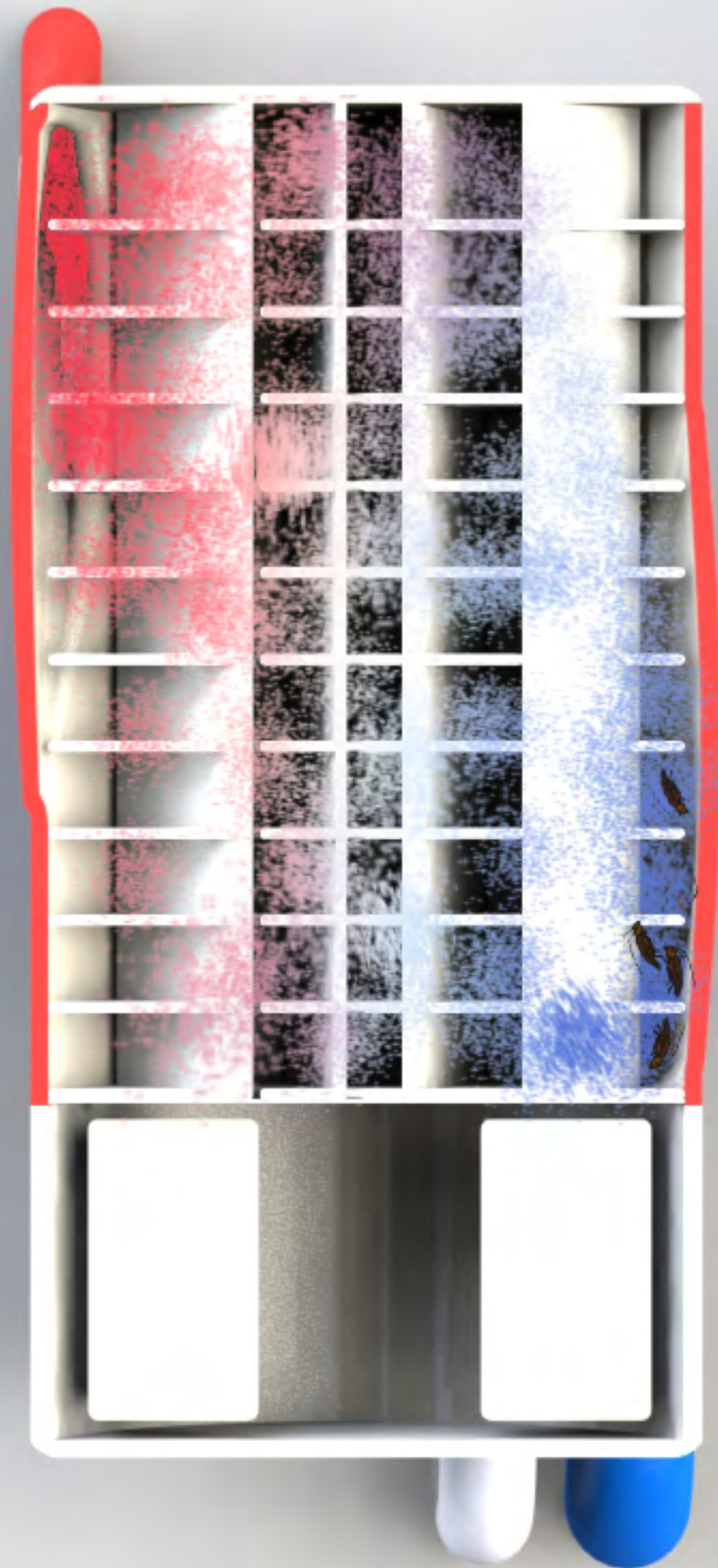
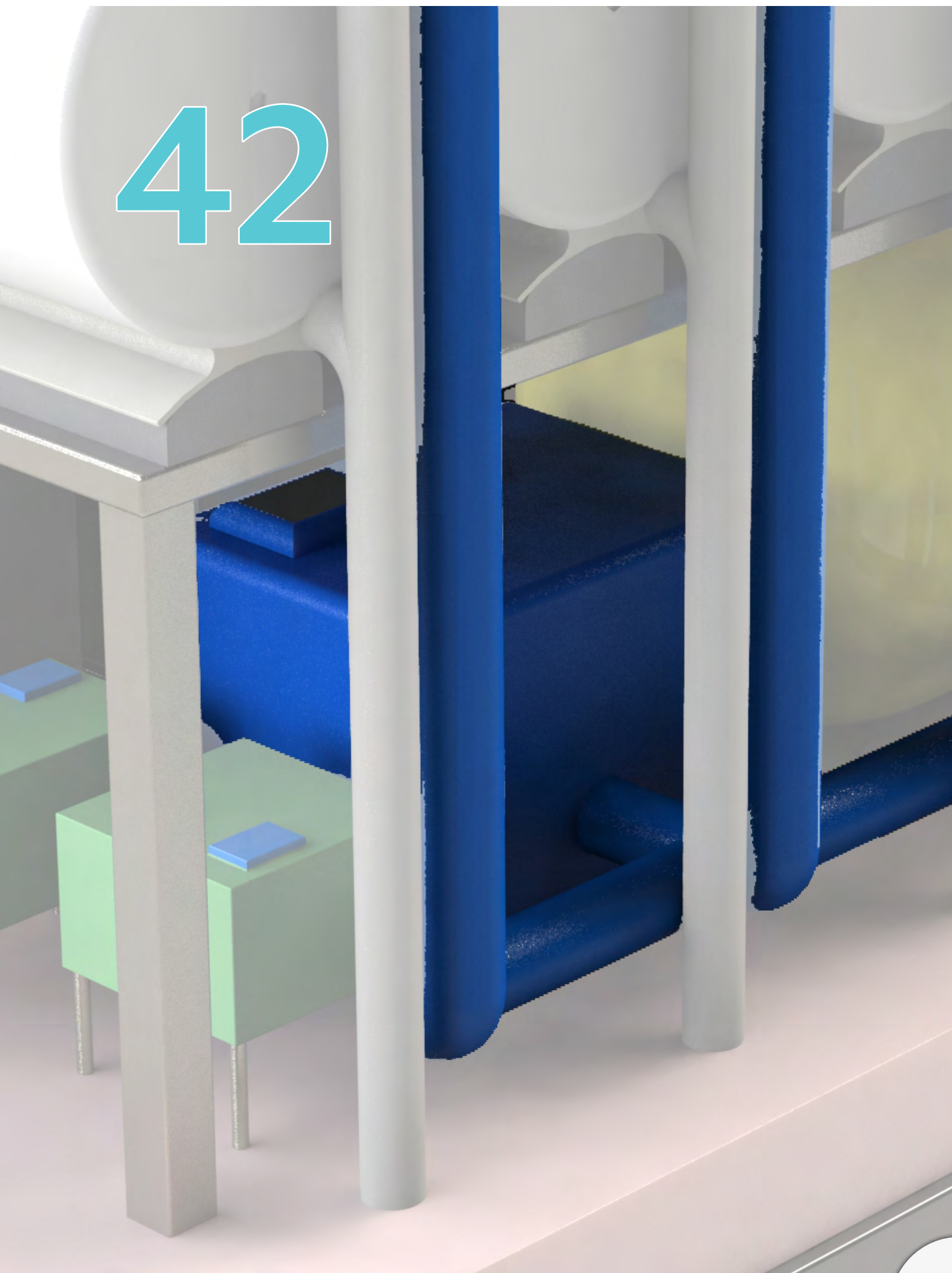
**2000
crickets**

Cricket Life cycle

42 days



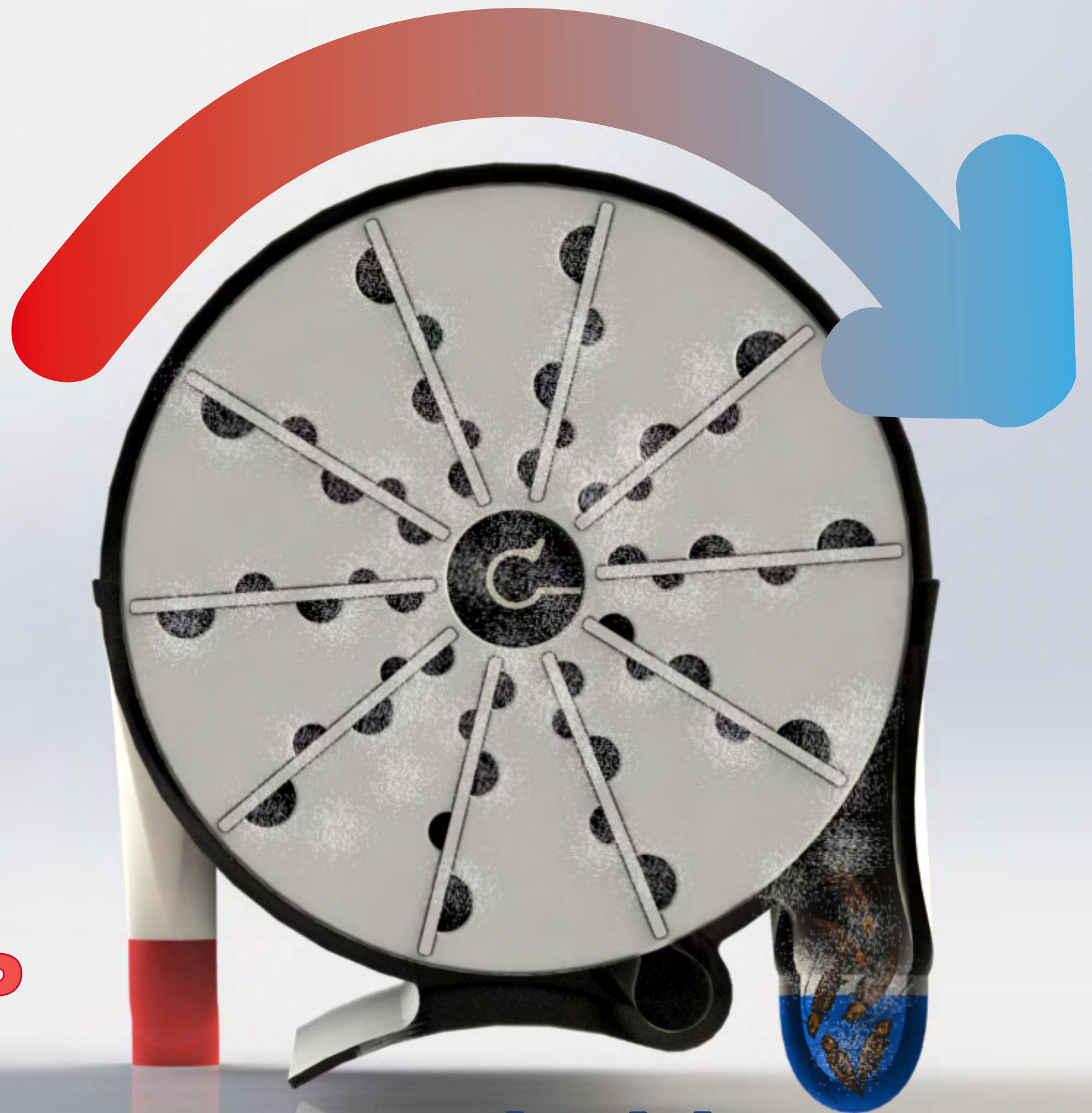
42



42



**high T high P
steam in**



**Dead crickets,
low T low P steam/water**



Product Design Specifications

Operation

- Cricket farming vending machine composed of 42x cricket farms and supporting subsystems for harvesting, cleaning, cooking, feeding and dispensing.
- One farm harvested each day (1kg live weight crickets), seasoned, roasted and dispensed.
- User chooses taste, temperature and grams

Dimensions in [m] or [kg]

- Each farm is 0.2x0.2x0.4, drives machine size
- Machine footprint 1.4x0.8
- Height 2.7-3
- Weight 250

Performance

- AC el. motor rotates each farm with 1RPH
- Electricity from the mains power
- Humidity range 40%-85%
- Temperature range 25°C - 35°C in farm, steam harvesting
- Steam temperature 125°C
- Product life - 20years
- Casing provides insulation and ventilation

Operating environment

- Best efficiency when kept indoors at room temperature

Materials and Manufacture

- For farm - predominantly Aluminium extrusion and sheet cutting
- Insulation - Polyurethane Foam 15cm
- Boiler, Oven, Dispensing unit - external manufacturers
- Machine shell - durable, simple aesthetics

Health and Safety

- No cricket escape guarantee
- Nut and Gluten free product guarantee
- Not recommended to people with sea food allergies

Maintenance

- Predominantly autonomous
- Feed needs delivered every two months

Price

- £4-7k

Develop

56 not 42	88
System Diagram	89
Motor business evaluation	92
Cricket requirements	93
Material Choice	96
Technical Detailing and Calcs	99

This chapter refines the detail around the vending machine. I have put some of the technical report pages inside, because I believe are quite relevant. I wish I had extracted them and put more emphasis on experimentation with cricket measurements, electricity calculations and etc.

56 not 42

Here I am going to go more in depth about the technicalities of the design.

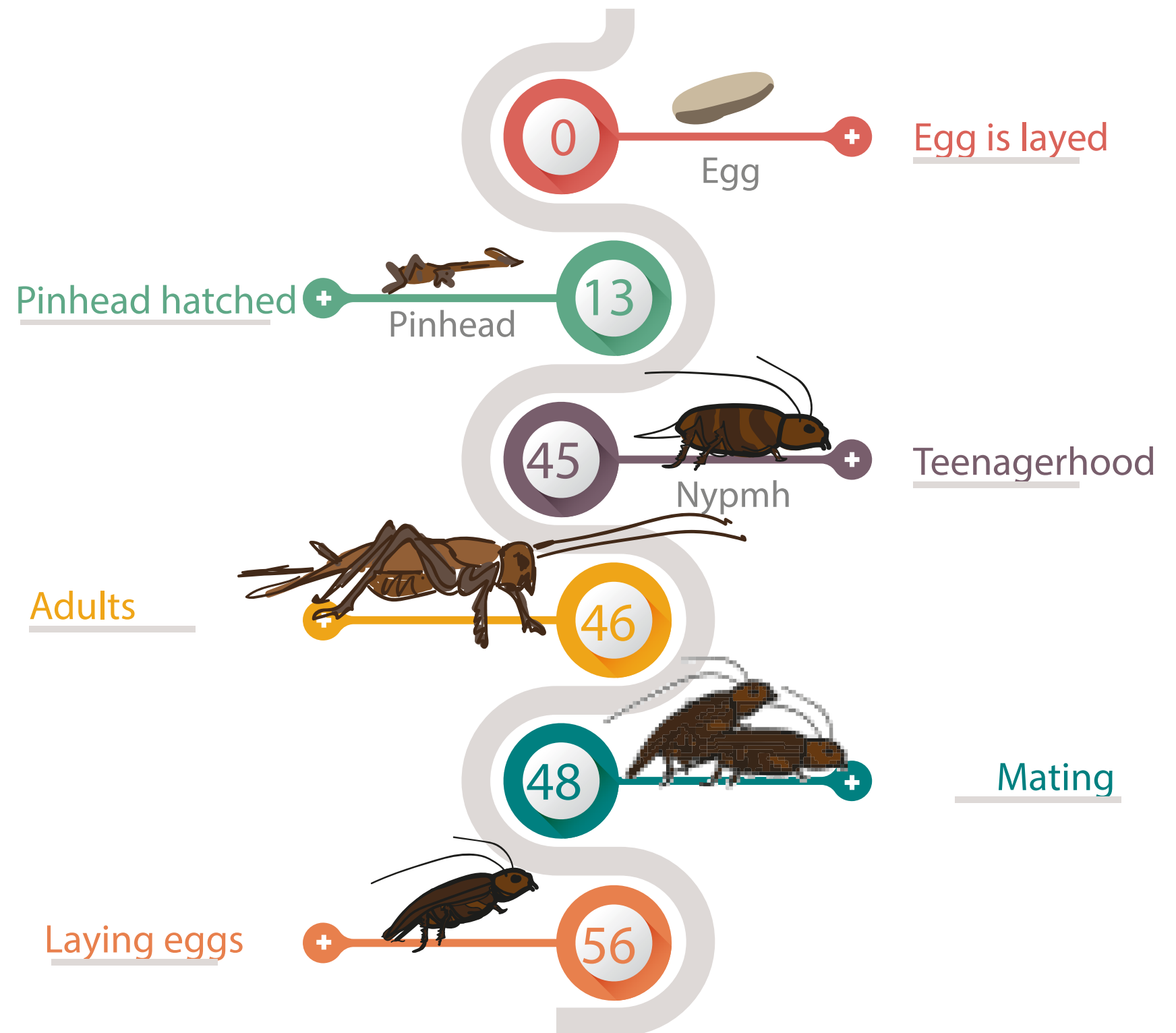
But first... OOooops! Chricket life-cycle mistake!
If I want a unit farm for everyday of the cycle, I need 56, not 42... cause hathing :D

It takes **56 days** from laying an egg to its development into an adult having the ability to lay an egg. That number has been the driver of the **56 farms** design.

It takes **13 days** from laying an egg to hatching a Pinhead - a small ant sized baby cricket.

In the stage the pinhead develops into a Nymph and moults (shedding its exoskeleton) 7 or 8 times until it becomes an adult. It takes **30-35 days**.

After the last moult, having grown wings, the cricket is considered an adult. 2 days of adulthood need to pass before cricket start mating and 7 more days until they start laying eggs.



System Diagram

The designed product is a scalable food producing, processing and vending machine. The examined size delivers an output of **1kg of live cricket weight** per day by harvesting one of the **56 cricket farms units**, each containing **2000 adult crickets** at the time of harvest.

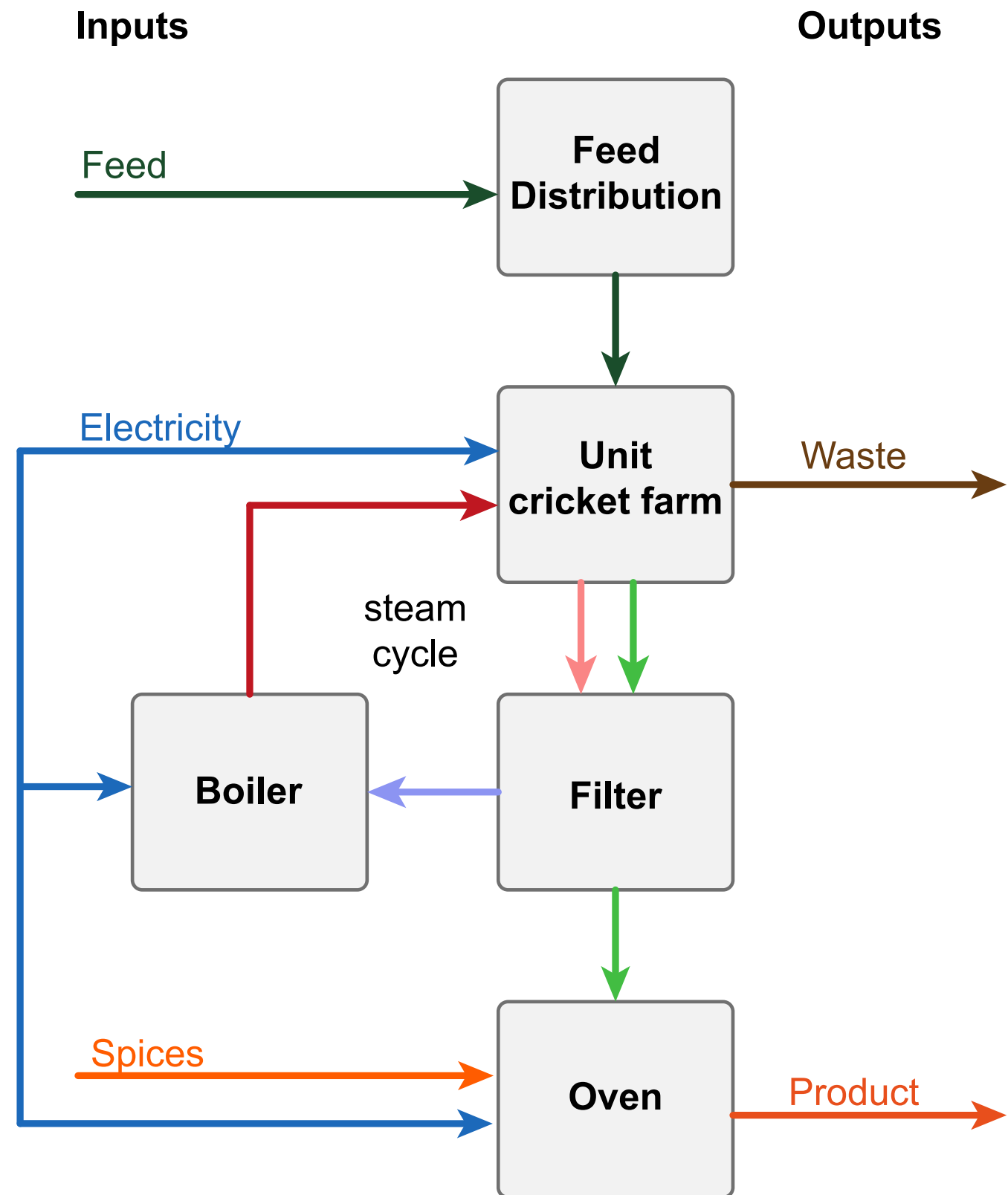
To make this possible, a number of subsystem machines and processes are designed.

The two most important factors for cricket breeding are feeding them properly and maintaining the correct temperature. These are achieved through the **feed distributing system** and **the living areas heating system**. The living areas in the cricket farms are maintained clean by a combination of the farm unit's design and a **synchronous electromotor** which each of them with one revolution per hour enabling the disposal of waste at all times.

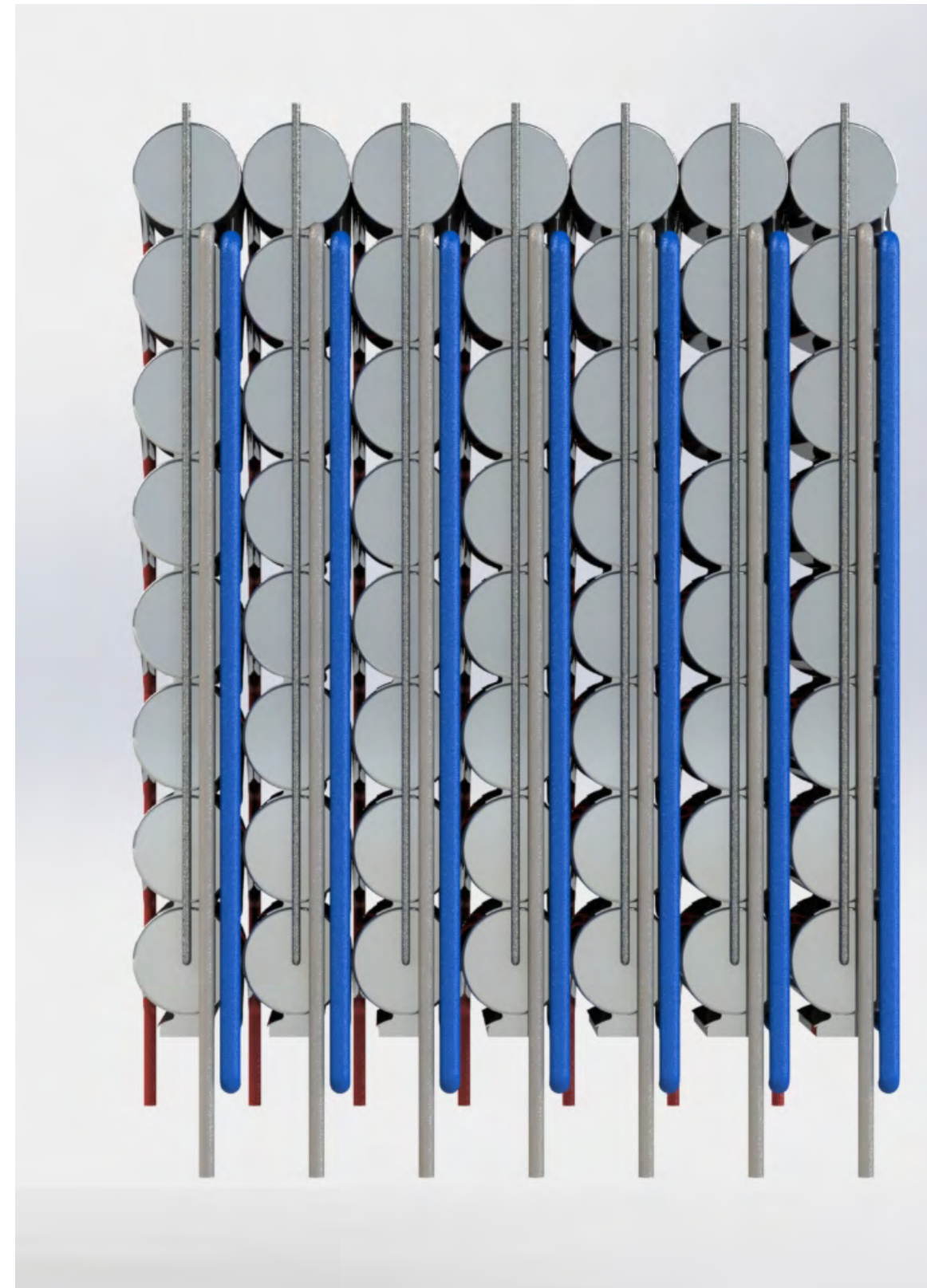
Hot pressurised steam is used to harvest the crickets after they have layed enough eggs to replace them. The steam is delivered from a **boiler** and slaughters them quickly while decontaminating the cage, thus preparing it for the next generation.

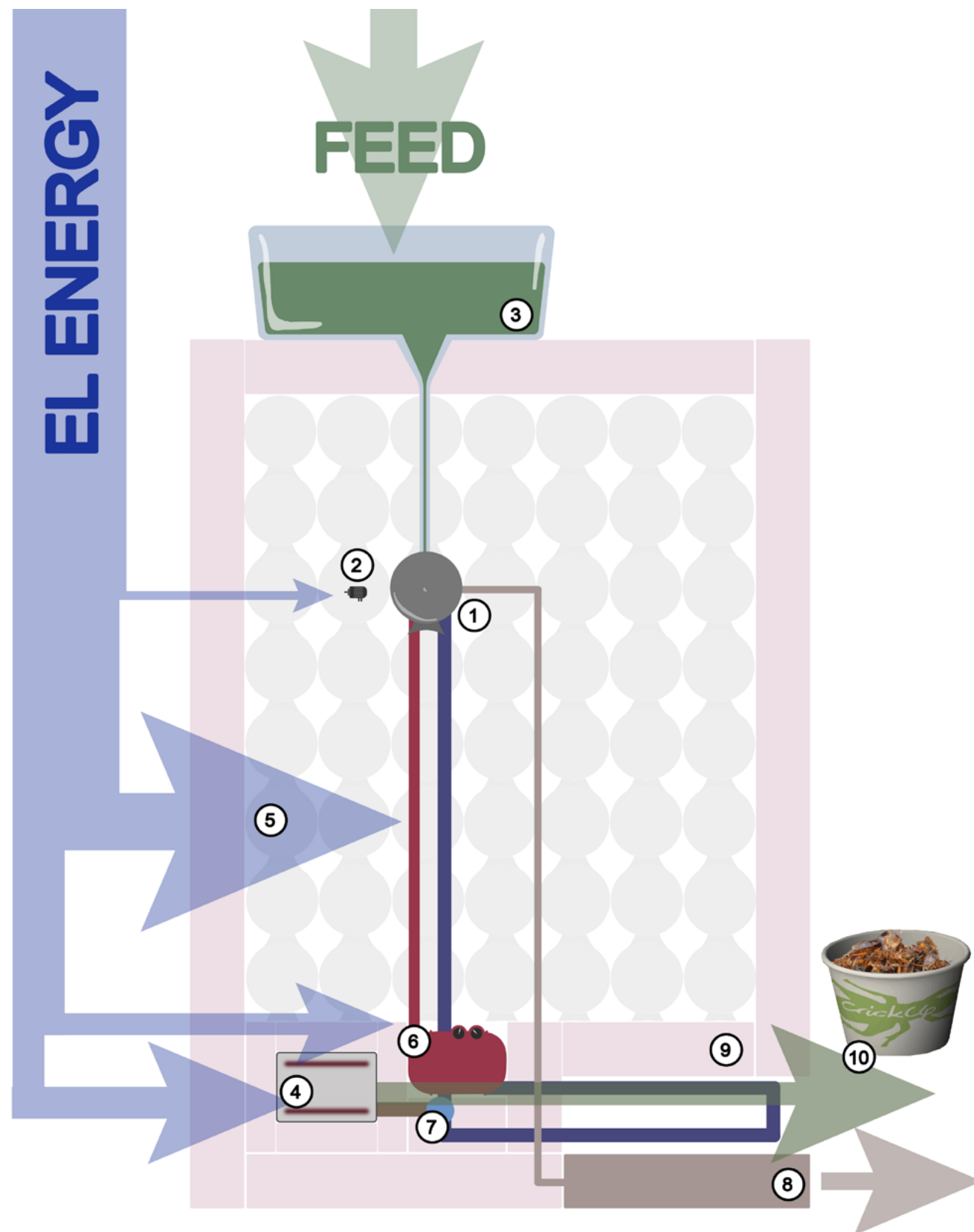
An outlet pipe goes through a filter which separates the dead crickets from the liquid, bringing the former to **an oven** and the latter back to the boiler.

After fat and spices are added in the oven. The final output has a a tasty crunch.

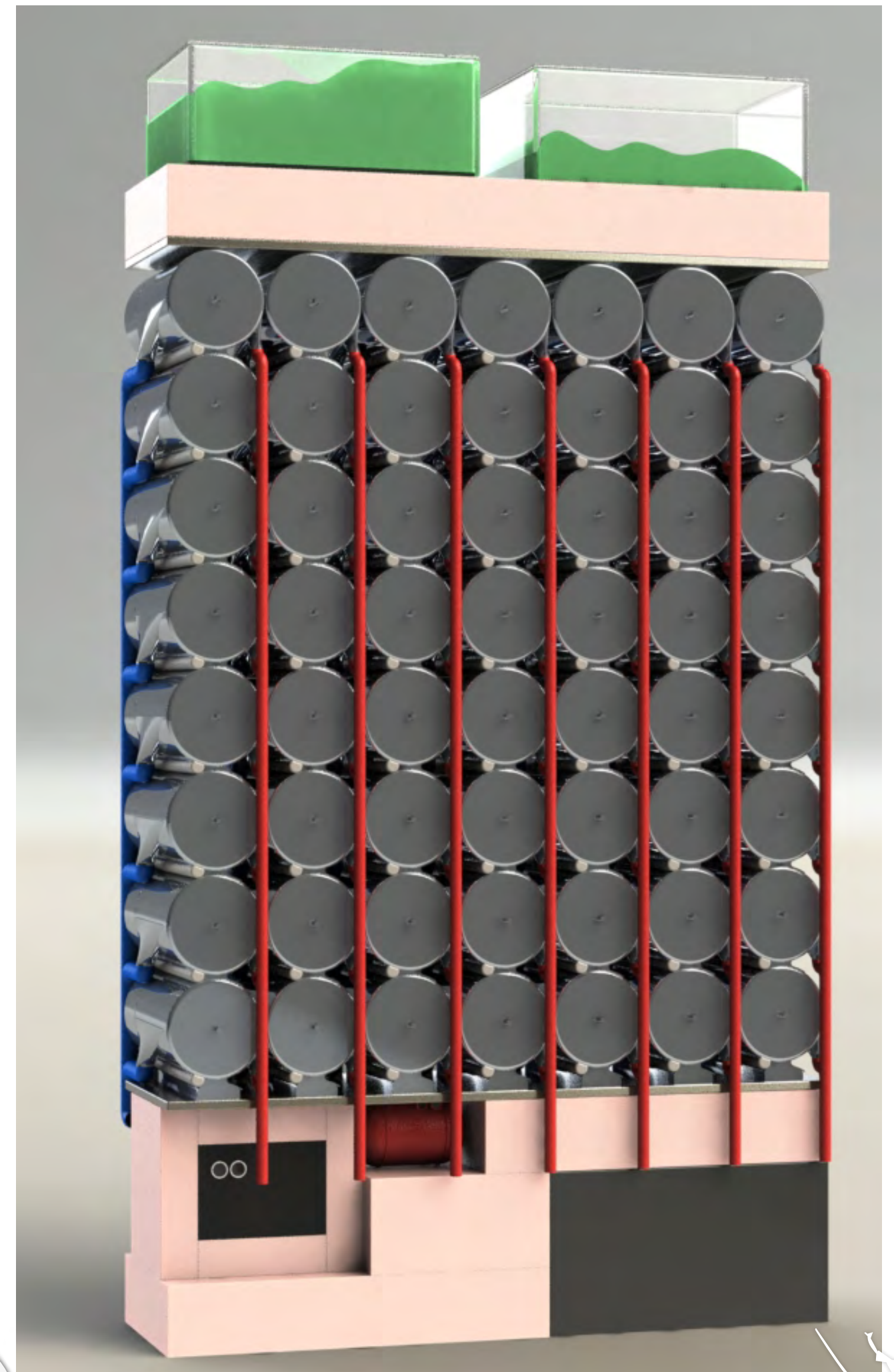


42 goes 56 cause hatching



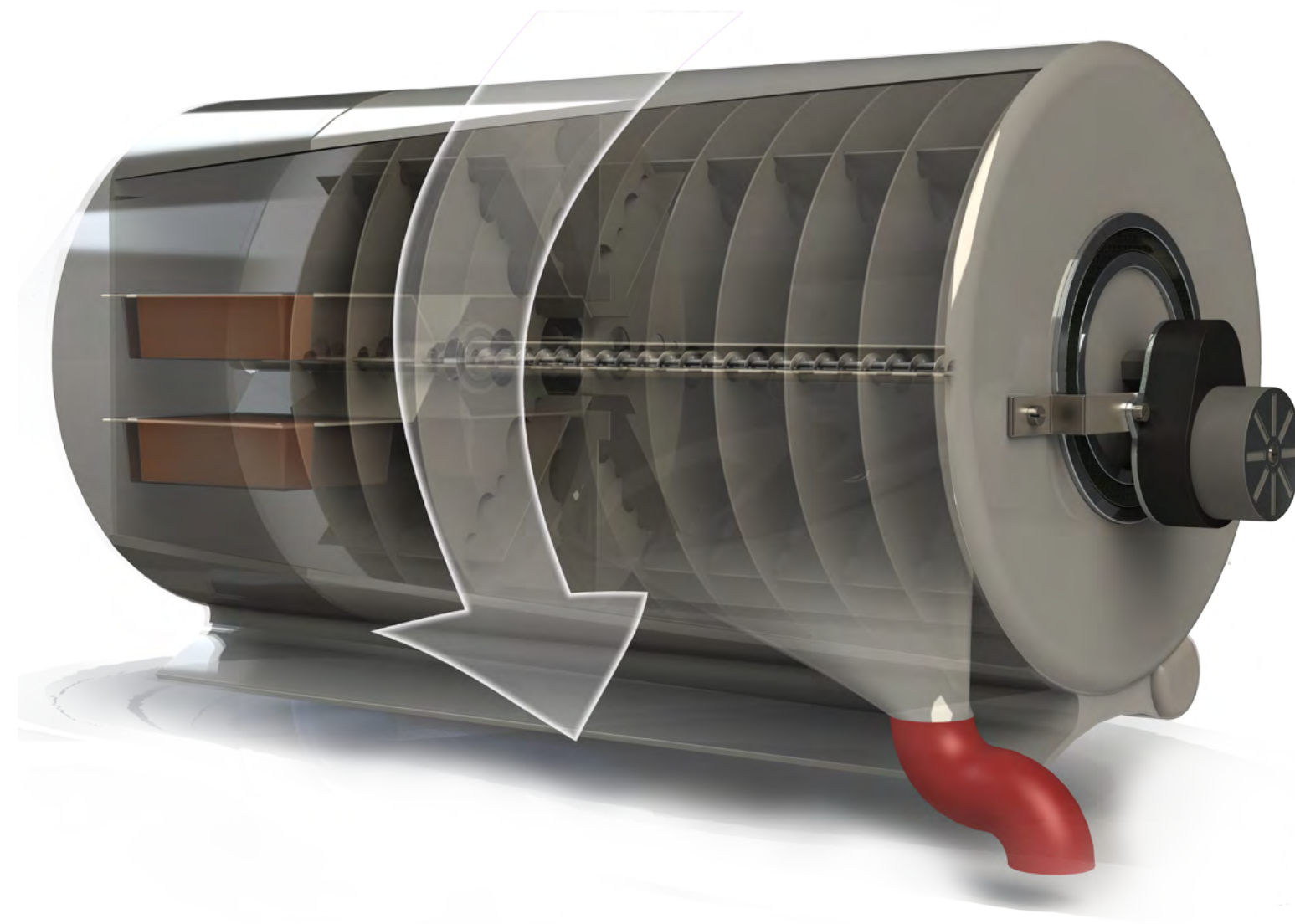


- | | |
|---|--|
| ① Unit farm, 2000 crickets x 56 | ⑥ Boiler and hot pipe |
| ② Synchronous motor, 1RPH x 56 | ⑦ Filter separating crickets and water |
| ③ Feed storage tank, 1 month x 2 | ⑧ Waste |
| ④ Oven, 220°C, 6 minutes | ⑨ Polyurethane Foam |
| ⑤ Heater for farm area of 1m ³ | ⑩ 0.5kg roasted crickets a day |



Motor business evaluation

One per column, one each, or one for all.. and what exactly?

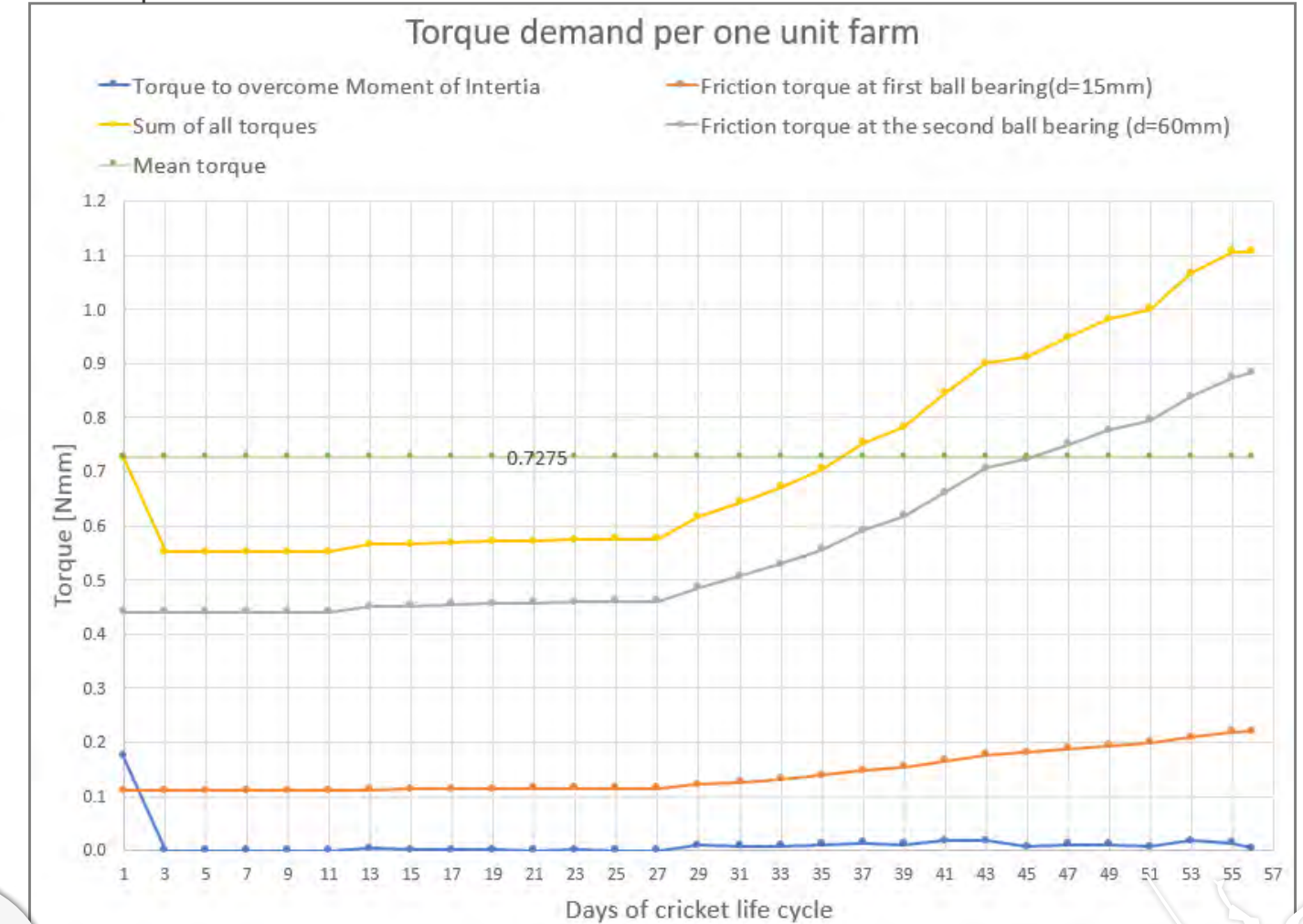


Why AC Synchronous motor

Rotating living spaces is one of the key design feature so choosing how to rotate is an important task.

Every cylinder rotates with 1RPH (0.0167rpm; 0.001745rad/s) for the entire cricket life cycle. Since it is such a low speed, and the torque required is not very large, it is sensible to have 56 separate motors controlled electronically rather than one more powerful motor and a lot of mechanics to translate the rotation across all farms.

The motor of choice is an AC synchronous electromotor. Its long life, simplicity of running and longevity are just part of the reason. The power it draws is used to monitor cricket growth. The motor maintains the same angular velocity independantly of the load. When crickets grow, more torque is required thus the motor draws more power.



Cricket requirements

Breeding

Temperature

The cricket life cycle varies greatly with temperature - faster development in warmer environment. A change from just 30.5 to 31°C results in a 10 day shortening of their life cycle and one day shortening of their hatching period. Thus, by controlling the temperature the output of the machine can be amended in accordance with the demand. (Clifford, C.W. & Woodring, J.P., 1990)

The insects can survive temperatures just a few degrees above 0°C. However, temperatures below 20°C are not advised for breeding due to greatly slowing down their life cycle.

Furthermore, temperatures above 35°C are lethal. 30°C is considered to be the optimum for breeding, despite of the fact that life cycle is a faster at slightly higher temperatures.

The **cricket farm living area temperature is to be maintained at approximately 30°C** and kept above 25°C and below 35°C at all times.

A heating mat covered with sand was used to heat the experiment farm with. A thermostat was utilised for control.

Light regime

It has been shown that **light does not play a significant role in cricket breeding.** (Clifford, C.W. & Woodring, J.P., 1990.). Cricket were kept in the dark - when container lid was closed. It has been noticed that crickets get scared when the lid is opened from the sudden increase of light. Personal experimenting also shows that they prefer hiding in the darkest spots available.

Feeding

The initial idea of this project was to combine the cricket farm with an algae farm so that the system is even more self-sustained, providing its own food. Due to the complexity of this undertaking and the scale of the project this idea was discarded. However, crickets were fed Spirulina (a type of algae) successfully.

After considering a few in depth studies about cricket feed it was decided to choose **Poultry feed as the main food source** since it is cheap and readily available. It also gives a good conversion ratio (kg dry feed per kg live weight) of 1.3 (Lundy & Parrella 2015).

Human food waste is also a great possibility with even better feed conversion ratio (Asnath Maria Fuah et al. 2015). Although this would increase the efficiency of the process, it will also complicate the system by introducing the requirement of preventing rotting of fresh food.

Rearing density

Studies suggest that density is another important factor for cricket breeding. The rearing group should neither be too large nor too small. Crickets in dense groups grow faster compared to when reared singly, However, too much overcrowding decreases the general well-being of the group. (Chauvin, 1958).

It was later determined that the minimum crawl space i.e. surface area per cricket is 2.5cm² (Patton, 1978). This allowance of living area gave the minimum rate of mortality and the maximum growth index after hatching. However, it is the optimised minimum so a bit more would be better.

The aim of the cricket living area design is to give 4cm² per cricket or more. Having 2000 crickets per unit farm yields **8000cm² of surface area per unit.**

Oviposition

Female crickets lay eggs 7 days after they have started mating with a rate of 95 eggs a day per female.(Asnath Maria Fuah et al., 2015.). 50 to 60% of the eggs hatch.(Clifford, 1990.).

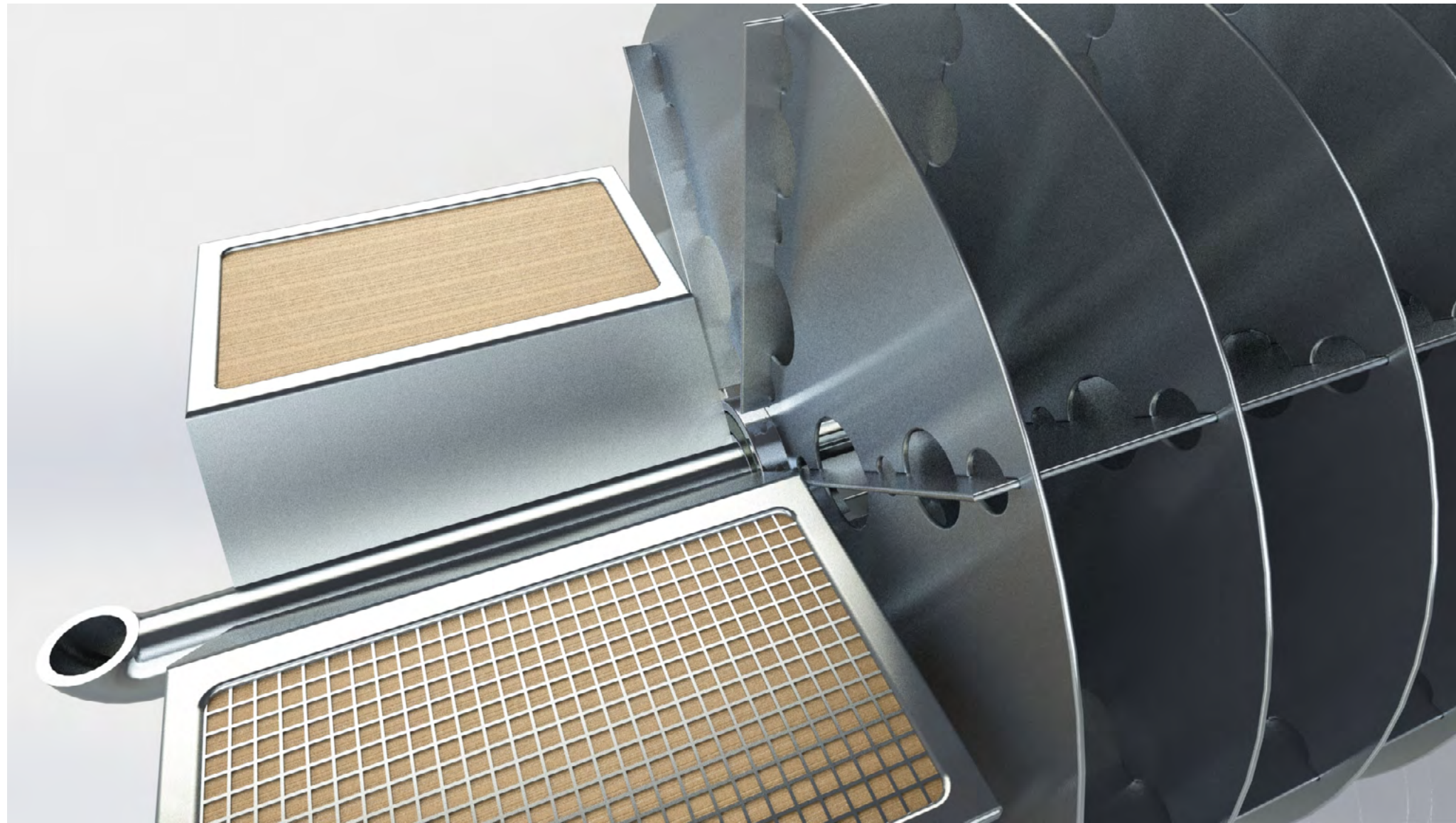
Egg laying trays have to be provided with a damp, relatively soft, egg medium so that the female ovipositor can lay an egg inside. Breeding has been done successfully using damp soil so it remains as the medium of choice.

It is important that the medium is protected with a mesh on top, otherwise male crickets dig in and eat a big percentage of the eggs.

Cleaning

It is important to maintain the rearing areas clean to prevent virus or parasite problems. Frequent removal of trash/litter storage is required. Keeping the egg laying trays separate from the main rearing compartment when not in use is also important. (Clifford, C.W. & Woodring, J.P., 1990.)

Many different ideas were tested for maintaining the living area clean at all times. The current design utilises a slow rotation of the units, while a jet of **hot steam** is used to decontaminate every unit farm after harvesting, thus preparing it for the next generation.



Harvesting

Initially, crickets were placed in the fridge where they hibernate and then moved in the freezer, to be slaughtered peacefully in their sleep. This would require a freezer integrated in the vending machine. However, it was later found that insects destined for human consumption should be first sterilized in hot water, which also agrees with the welfare of farmed insects. (Erens, Jesse et al., 2012). This led to the choice of **hot steam** being used for cleaning and harvesting purposes.

Experiments proved it is working successfully for both (fig 10)

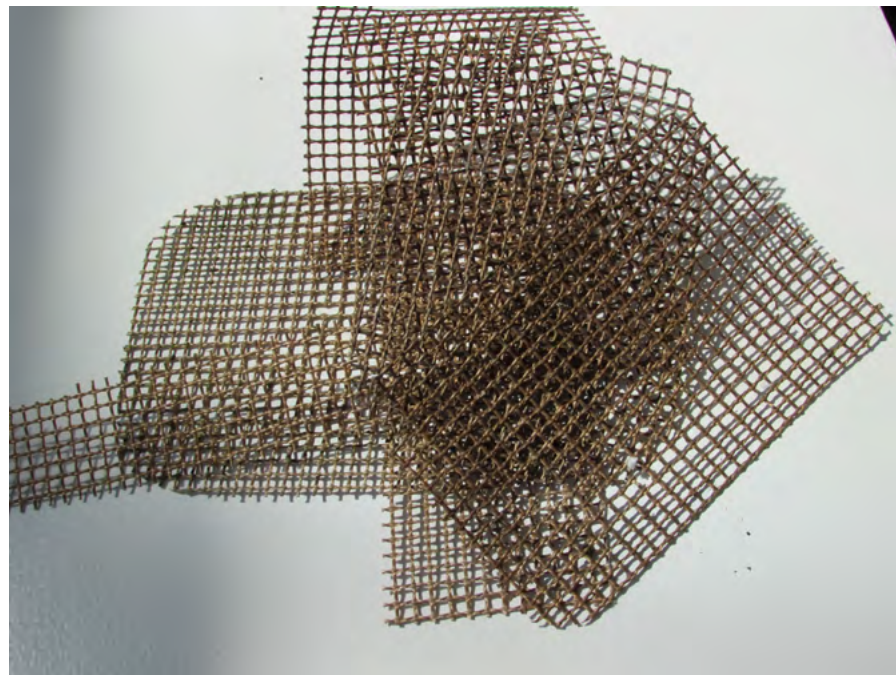
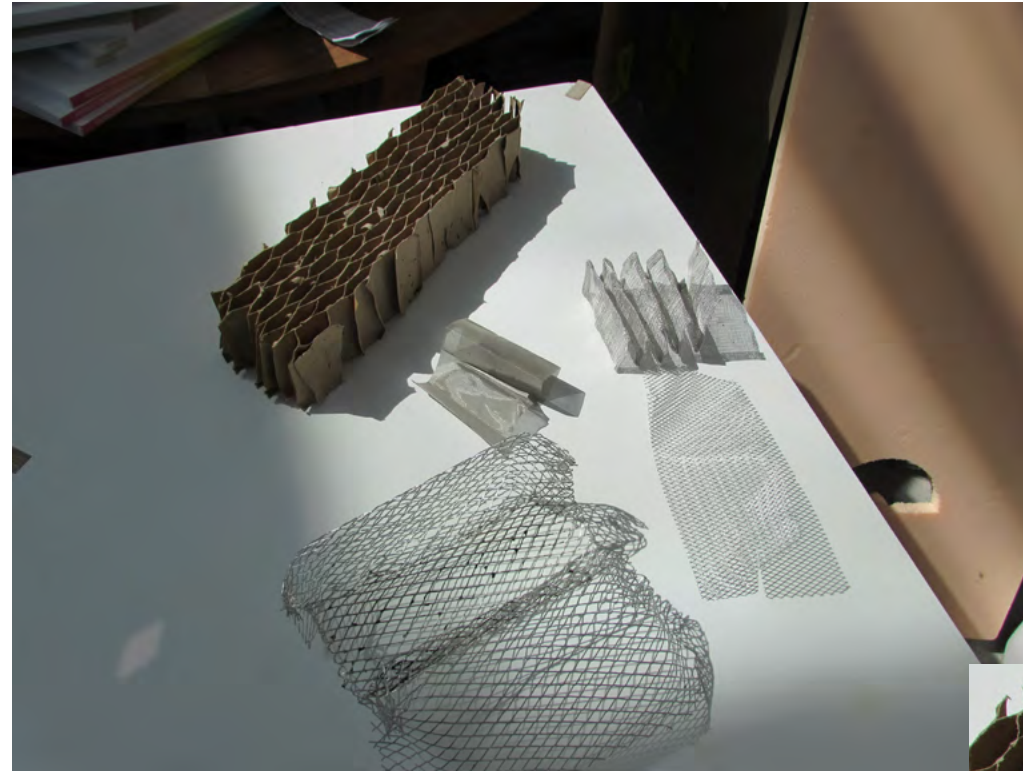
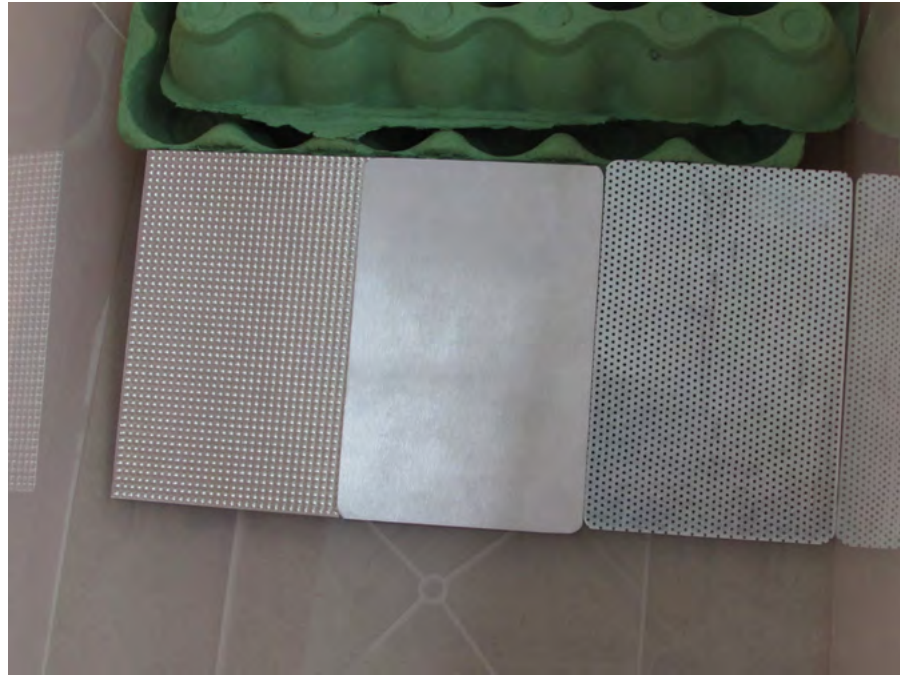
Cooking

Although harvesting crickets in this manner automatically cooks them (i.e. boiled), experimenting showed that oven roasted crickets with very little oil and spices makes them very tasty (see appendix).

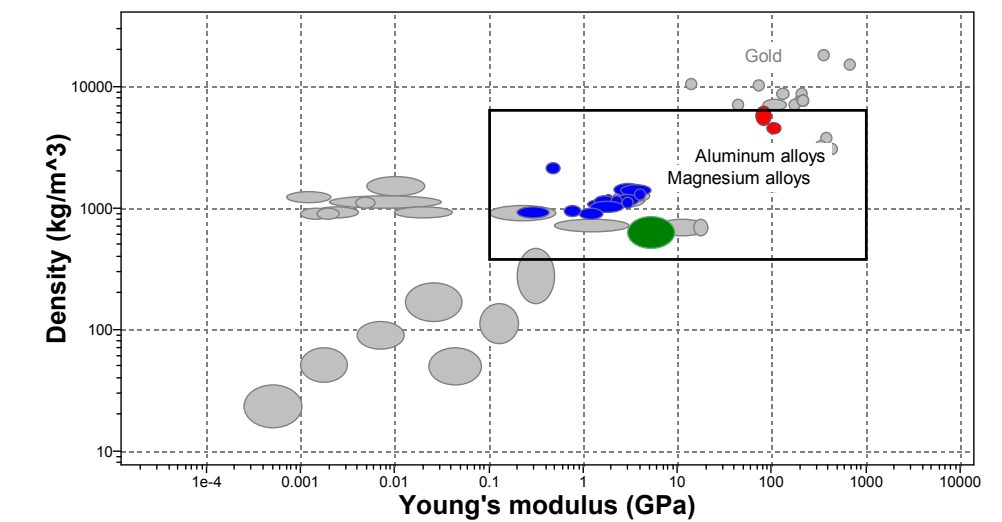
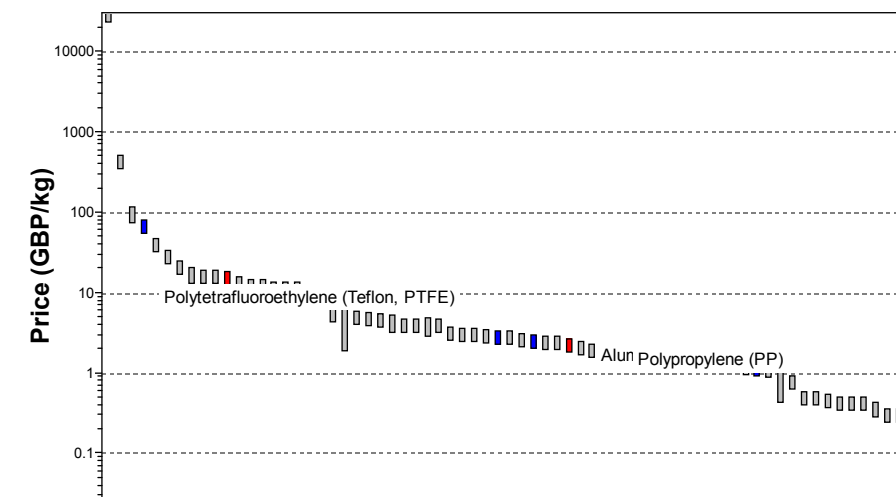
Three roasting temperatures were tested (180°C, 200°C and 220°C) to investigate the required times for roasting and the difference in taste quality. It turned out that roasting them at **220°C for six minutes** gave the best results. Cricket mass decreased in half after roasting. (See Appendix B, 1)



Material Choice



crickets eat through not metal mesh!



CES EduPack 2016 (C) Granta Design Ltd

CES EduPack 2016 (C) Granta Design Ltd

I want it recycleable, strong and cheap :)

Testing with crickets

The were climbing both of my awesome house prototypes. So i guess it works.

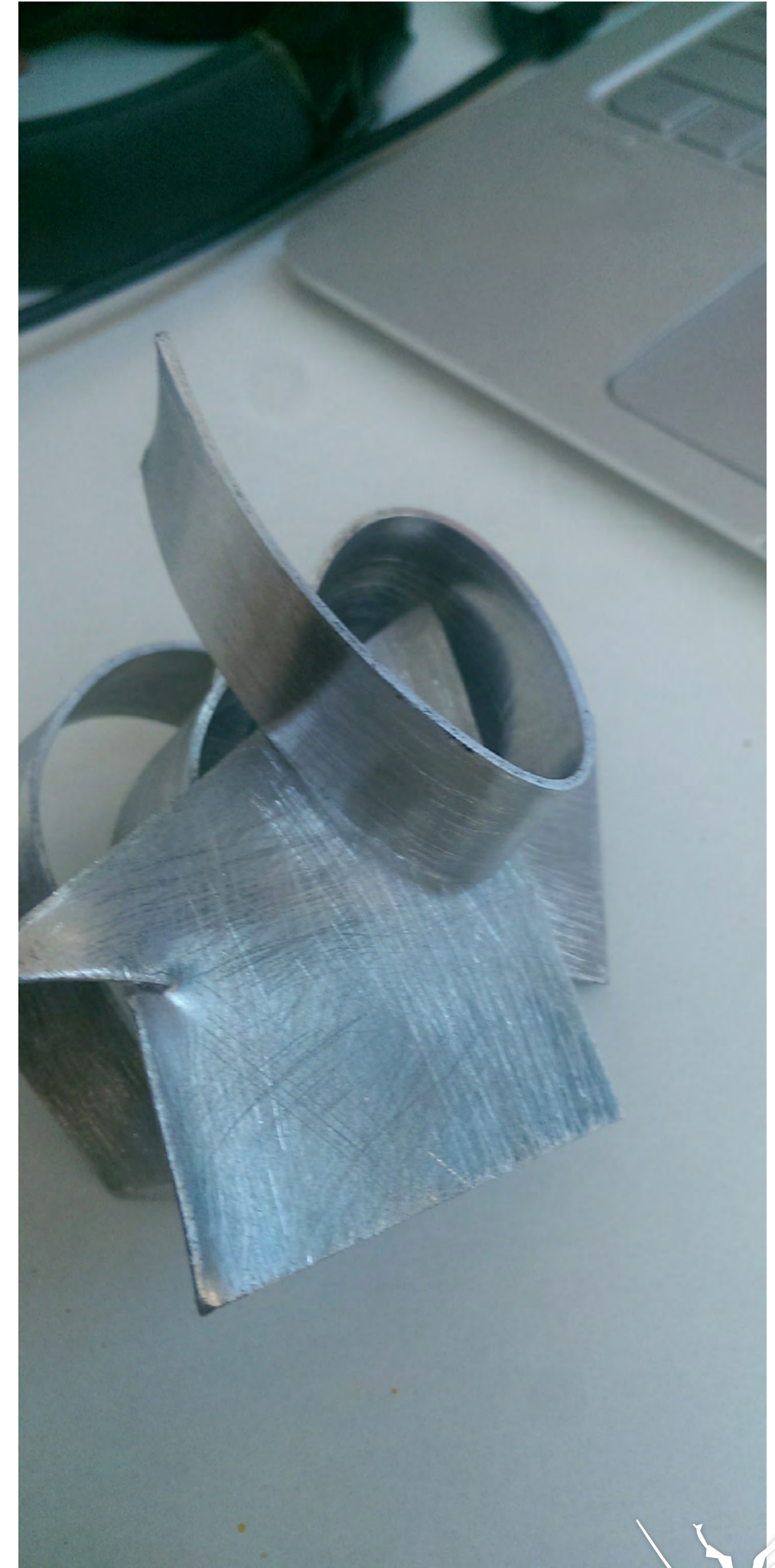
CES material selector together with experimenting with crickets themselves were used to determine the main unit farm material.

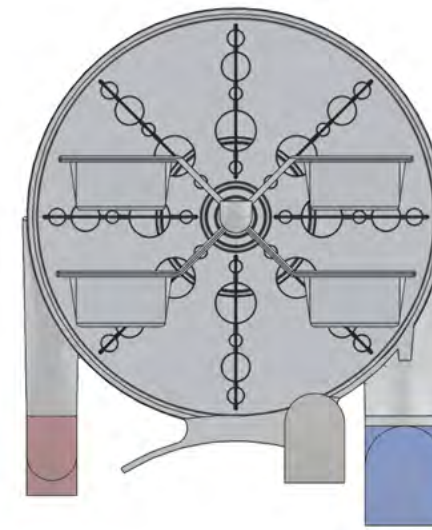
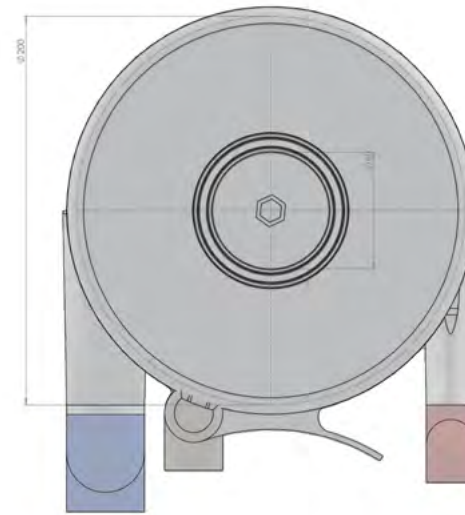
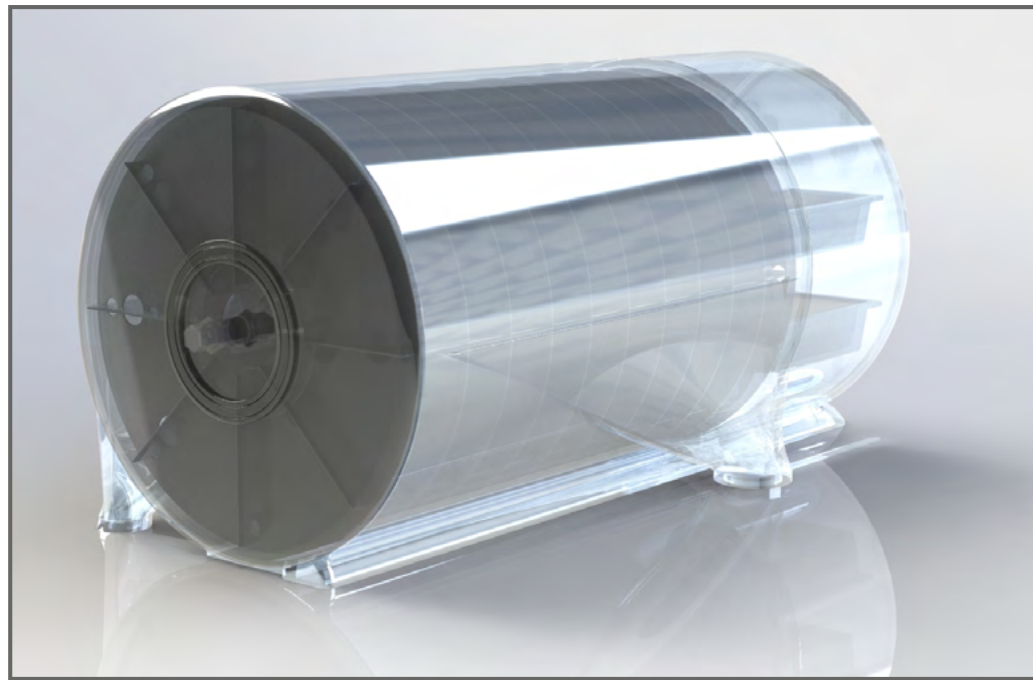
Since it is a machine with strong environmentalist character, low CO₂ footprint and recycleability were very important features. Resistance to corrosion and formability were also important due to the geometry of the unit.

Aluminium and a few types of thermoplastics appeared as the most suitable choice.

Aluminium was chosen due to cost, longevity and high heat conductivity which helps to thermally unify the area of the machine the farms are in.

Extrusion seemed like the obvious choice for the case of the unite, therefore Aluminium grade 6063 was chosen due to its extrusion friendly and corrosion resistance qualities.





The novelty in the automated cricket vending machine design lies in the rotating farming unit. This provides very large surface area for its small volume. The dimensions of the unit were driven by the surface area needed for 2000 crickets which was decided to be not less than 8000cm^2 .

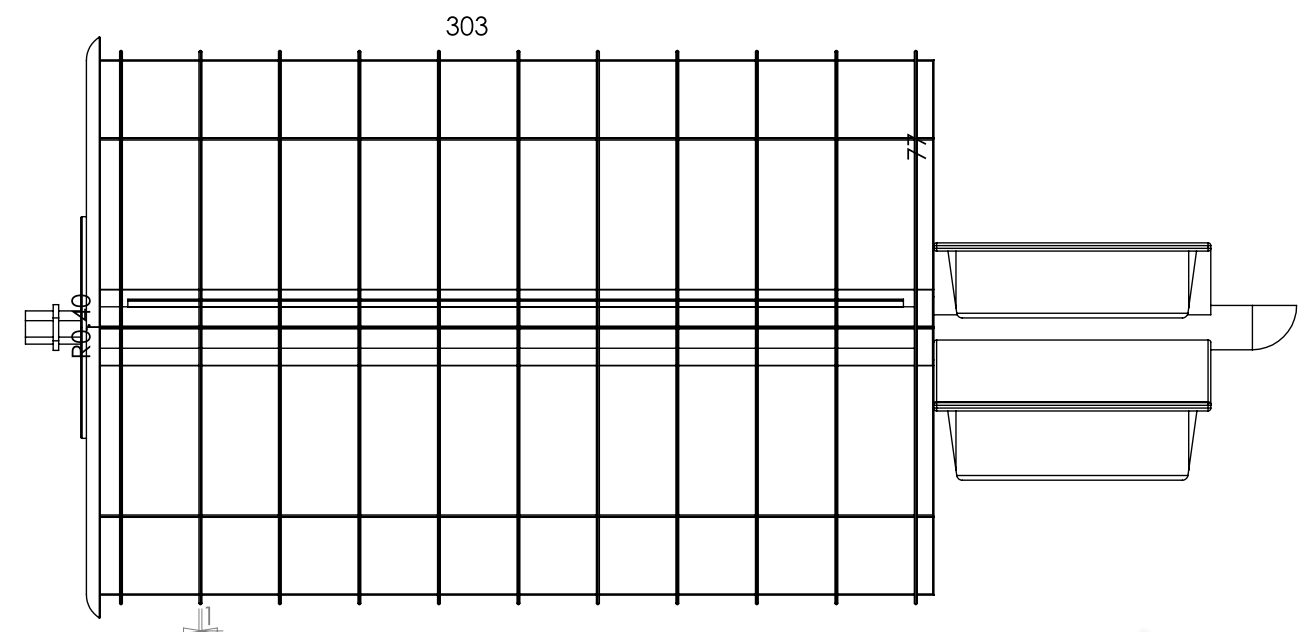
The unit is divided in 11 circular plates for **living area**, perforated to allow free movement, and 8 perpendicular rectangular squares, providing a total surface area of **8327cm^2** . There is a feeding pipe running through the centre of the unit providing the necessary nutrition. The living area rotates with 1RPH coaxially to the **feeding pipe** via two ball-bearings and a synchronous motor. The rotation is slow enough not to be noticed by the insects, and gravity is utilised to collect the waste in an outlet pipe through which it gets disposed.

The **egg laying/hatching area** is opened only when crickets are ready to lay eggs, right before harvesting. It consists of **4 egg laying trays** containing damp soil and a mesh on top.

Hot steam harvesting takes place after a sufficient amount of eggs have been laid (approximately 2 to 3 hours). 13 days later the hatching area opens to the living area and the new generation moves in.

The two areas are united with the casing which contains the waste pipe at its bottom side, thereby enabling the stacking of the farms on top of one another possible.

Technical Detailing and Calcs



Materials and structural verification

Aluminium

CES material selector together with experimenting with crickets themselves were used to determine the main unit farm material.

Since it is a machine with strong environmentalist character, low CO₂ footprint and recycleability were very important features. Resistance to corrosion and formability were also important due to the geometry of the unit.

Aluminium and a few types of thermoplastics appeared as the most suitable choice. **Aluminium** was chosen due to cost, longevity and high heat conductivity which helps to thermally unify the area of the machine the farms are in.

Manufacturing

Extrusion seemed like the obvious choice for the case of the unit, therefore Aluminium grade 6063 was chosen due to its extrusion friendly and corrosion resistance qualities.

The grade of Aluminium, the shape of the casing and the method of manufacturing suggest wall thickness of 3mm (Appendix B, 2). It is important to verify whether the units can structurally withstand the loads of the farms stacked on top of them.

Structural Verification

A linear elastic finite element analysis is performed to verify the structural viability of the cricket unit design in the most conservative case - having 7 fully loaded unit farms stacked on top.

Geometry

To enable a quick and reliable analysis the geometry is simplified to a cylinder defined by a 200mm diameter and 400mm depth.

Material properties

For the purposes of this analysis the following aluminium material properties are used:

Young's Modulus = 69×10^3 N/mm²; Poisson's Ratio = 0.35; Density = 2700 kg/m³; Yield Strength = 240 N/mm²

Support

A surface defined by a 40° section of the cylinder's diameter is restrained in all 3 translational degrees of freedom to model the support conditions of the cricket units (see fig. 13)

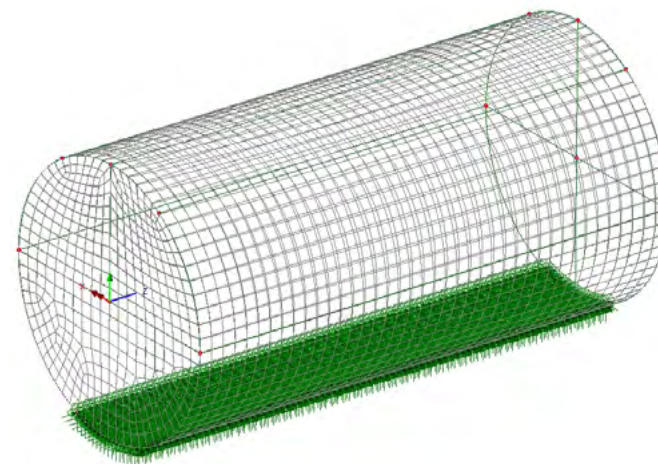


Fig. 13 - Support Conditions

Loading

The cricket units are stacked on top of each other. Therefore, only the bottom unit is investigated in this model, as it is expected to be most heavily loaded. The load is applied transversely to the cylinder wall as a 15kPa static uniform pressure applied on a surface defined by a 65° section of the cylinder's diameter (see fig. 14). To account for the variability of loading over the unit's design life a safety factor of 1.35 is used on all material loads and a factor of 1.5 on the cricket loading.

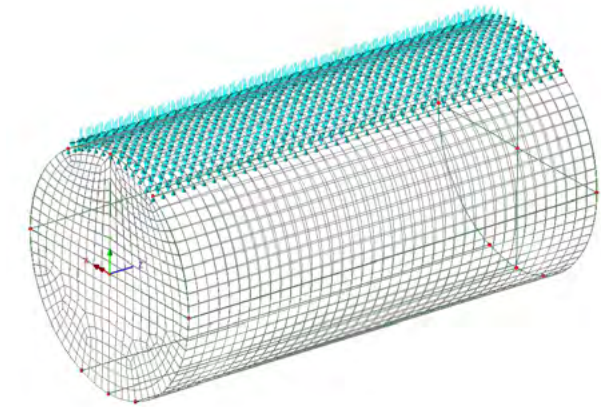


Fig. 14 - Nature of Load Application

A breakdown of the loading from a single unit: (1.5 Factored Loading)

Item	Material	Load (N)
Casing	Aluminium	55
Shaft (feed pipe)	Aluminium	4
Living area (rotating part)	Aluminium	18
Egg laying trays	Gravel	2
Crickets	Insects	15

Results

The magnitudes of displacement show maximum deflection to be much less than 1mm.

Considering that the gap between the casing wall and the rotating living area units is 2mm, this deflection can be comfortably allowed for in the design.

Stresses are also well below the threshold of 240MPa. (Aluminium Yield Strength)

It could be concluded that the choice of material and construction is a viable one even more unit farms are added to the design.

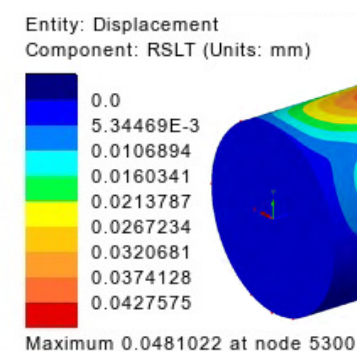


Fig. 15 - Displacement

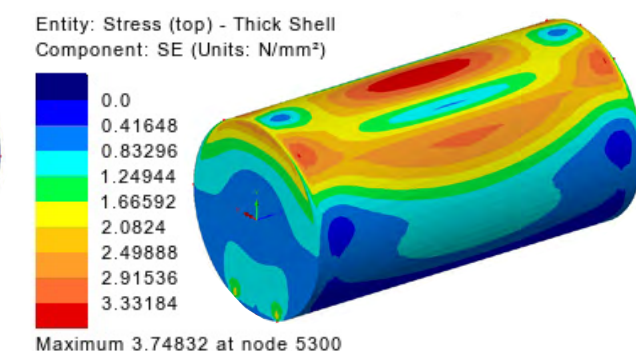


Fig. 16 - Stresses

Control

Autonomously operating a complex system with several subsystems and living organisms requires an integration of multiple sensors in a **coherent automatic feedback control system**.

The report does not get into the details of the closed loop diagrams illustrating the control system. It outlines its importance with examples in the proposed design.

Temperature control

Maintaining efficient cricket breeding depends greatly on maintaining the right temperature. Switching the heating on and off at the right time, although simple, is crucial for the design.

A good design solution was to use aluminium and to maintain the same temperature across all the living farms space so that only few sensors are required instead of 56 - if controlling every farm unit separately.

As explained earlier, this particular insect life cycle can slow down or speed up depending on demand i.e. if there are holidays the temperature can be lowered as if to “pause” itself for some time. This is a very significant feature when living beings are what is dealt with.

Cricket managing

It is important to know the rate at which crickets grow as well as the time it takes for a sufficient number of eggs to be laid.

Both of these considerations could be taken care of simply by monitoring the change of weight.

4 weight sensors (pressure mats) under each egg laying tray are responsible for getting 3000 eggs measured.

Having the living area spun by a synchronous motor makes monitoring the growth an easy task. The motor maintains the same angular velocity and when the load changes, the torque changes thus drawing more power. This is looked into more detail further in the report.

Feed

It is natural that feed demand changes with cricket growth. Combining the feedback from the synchronous motor power draw change with the feed distributing system is important in order to minimise waste of resources.

Pressure

Hot steam is used to harvest the crickets and decontaminate the farm. The jet is delivered from a boiler through a distributed flow inlet pipe, across the living area of the cricket farm. Building pressure in the unit before exiting helps cleaning and harvesting processes. Having a controlled valve at the outlet pipe can serve for this purpose. Pressurised steam is very dangerous - it should be controlled meticulously.

4. Energy for system operation

One of the objectives of this report is to investigate whether producing food in this way is energy efficient. Energy calculations were performed to address this consideration.

Feed and electricity constitute the main energy demand.

Feed

As mentioned in the previous chapter Poultry Feed will be used to feed the crickets at that stage of the project which gives a feed conversion ratio of 1.3 i.e. **1.3kg** of feed required for **1kg** of live weight.

Price

Average market price for chicken feed is £7 per 25kg which yields **0.28 pence per kilogram**. (Mole Valley Farmers, 2017)

Since the machine is producing 1 kg of crickets a day, it could be safely concluded that it requires 1.3 kg of feed to maintain that rate amounting to **0.36 pence per day**.

This could be rounded up to **40p** a day to include losses which yields **£146 a year**.

Volume

It is important to decide how often the feed storage containers should be refilled to determine their size.

To find the volume required, by already knowing the mass, it is required to find the density of the feed. This was done by measuring the mass of 25ml feed. (Fig. 17)

25ml of feed = 18 grams

$$25ml * \frac{1300g}{18g} = 1805.5 = 1.8l$$

The volume for a **month's supply** is then **54l with a mass of 39kg**.

It could be safely assumed that storing food for at least a month is not a problem. The current design has two containers, a month's worth of feed each.

Distribution

Feed is to be distributed in the feed pipe along the living area via an Archimedes screw. It could be attached to the electromotors spinning the unit farm. The amount of feed delivered should be controlled to correspond to the demand changing with cricket growth.



Fig. 17 - Measuring density of feed

Electricity

It is very difficult to estimate all the electricity uses in a design at this stage. For that purpose the report concentrates on the electricity used for heating and for rotating the farm units. When calculating the total energy there are *Others*, approximated systems not taken into account.

Electrical Energy into Heat

Apart from feed energy, electricity is consumed to heat up the oven for roasting the crickets once a day for 6 minutes at 220°C, as discussed earlier. Also all living areas should be maintained at roughly 30°C, not going above 35°C or below 25°C. Last but not least - water should be heated up to 125°C to steam harvest the crickets and decontaminate the area.

Total electrical energy for heating = Electricity to run the boiler + Electricity to run the Oven + Electricity to heat the farming area.

The oven uses **8cm** of **Polyurethane Foam** with thermal conductivity of **0.003 (W/(m·K))**, for insulation, the living space utilises a **15cm** thick layer of the same material.

Electricity to run the boiler

To calculate the energy required to boil water from 30°C (considering the boiler is in the heated up cricket living area) and turn it into steam of 125°C, the amount of fluid in at least one of the states of matter should be known.

The volume of water required could be reversed engineered from the volume of steam necessary.

The maximum volume of steam required can be estimated to be filling the full pipe length to the farm unit furthest away from the boiler. It is the volume of the unit plus the inlet and outlet pipes.

Volume of the living area (cylinder with a radius of 10cm and a length of 30cm) is **9425cm³**.

Maximum length of the inlet pipe with a radius of 7.5mm is 2150mm which gives a volume of **380cm³**.

The outlet pipe has a radius of 15mm and maximum length of 2250mm, so its volume is **1590cm³**.

The the total volume is **11,395cm³**.

Knowing that steam has 1700 times the volume of its corresponding amount of water, it can be calculated that the volume of water needed boiling is **6.7cm³** of water which equals to **6.7grams** of water.

In order to be able to raise the pressure above 1 bar if necessary (this will be controlled by sensors and valves), the energy required for **10 grams** instead of 6.7 is calculated.

The heat loss to the surrounds is not taken into account in this case due to very small surface area and a short period of heating.

Calculating the energy is done in three steps:

(1) energy necessary to heat up water from 30°C to 100°C using the following equation:

$$Q = c_p m \Delta T \quad (\text{Lienhard, 2008})$$

Where c_p is the specific heat capacity of water 4.184 J/gK, m is the mass of water 10 grams and ΔT is 70°C.

$$Q_1 = 2928.8J$$

(2) energy required to turn water at 100°C to steam at 100°C using

$$Q = mL \quad (\text{Lienhard, 2008})$$

Where L is latent heat of vaporisation 2266 J/g, m is still 10 grams.

$$Q_2 = 22660J$$

(3) energy to get the steam up to 125°C using the equation from (1) with c_p being the specific heat capacity of steam which is 1.865 J/gK and ΔT is 25°C.

$$Q_3 = 466.25J$$

$$\text{Total energy} \quad Q_{\text{boiler}} = Q_1 + Q_2 + Q_3$$

$$Q_{\text{boiler}} = 26055.1J = 26055.1Ws$$

If the water is turned to steam for **1 minute** it will require **434 W**

$$E_{\text{boiler}} = 434.3W * \frac{1}{60}h = 7.23Wh$$

Electricity to run the oven

As indicated in the previous chapter, the oven needs to maintain 220°C for 6 minutes and 8cm of Polyurethane Foam is used for insulation. However, to calculate the energy required to generate and maintain the heat, the volume and surface area of the oven need to be known.

Firstly, the space required to roast 2000 crickets needs to be calculated. An experiment was conducted in order to estimate the surface area required. (Fig. 18 on the next page)

It showed that 30cm² is required to roast 20 crickets. Therefore, 3000cm² will be then required for the daily roast.

In order to understand what would be the best overall shape of the oven, the different volumes and surface areas were calculated trying out various oven levels. To keep them to minimum, a square footprint was chosen. Variations with different levels were calculated (see appendix) and a 4 level oven with height of 18.5cm and a square base with a side 27.4cm was chosen. This results in 13899cm³ volume and 3529cm² surface area.



Fig. 18 - Roasted crickets on graph paper

To find the energy required to heat the oven up the following equation is used:

$$Q = \rho V c_p \Delta T \quad (\text{Lienhard, 2008})$$

Where ρ is air's density 12578g/m³, V its volume 0.0139m³, c_p is specific heat of air approximated to 1 J/gK and ΔT is 190°C.

$$Q = 33212J = 33212Ws$$

If the oven is heated up for 10 minutes the energy required is **55.4W**

The rate of heat loss when heated up via conduction could be calculated having chosen the insulating material and its thickness of 0.8m.

$$\dot{Q} = kA \frac{\Delta T}{x} \quad (\text{Lienhard, 2008})$$

Where k is thermal conductivity of polyurethane foam 0.003, A is the oven surface area of 0.353m², ΔT is 190°C and x is the insulation thickness of 0.08m.

$$\dot{Q} = 25.2J / s = 25.2W$$

Heating up is for 10 minutes, while maintaining the temperature for 5 more, total oven energy per day is:

$$E_{oven} = 55.4W * \frac{1}{6}h + 25.2W * \frac{1}{12}h$$

$$E_{oven} = 9.23Wh + 2.1Wh = 11.33Wh$$

The graph shows it takes the oven 10 minutes to heat up and more than 2h to cool down.

Electricity for heating up the living areas

The volume of the living areas, containing all the 56 unit farms is **1m³**.

Surface area is **7.6m²**

As mentioned earlier, there is 0.15m insulation using polyurethane foam with thermal conductivity of 0.003

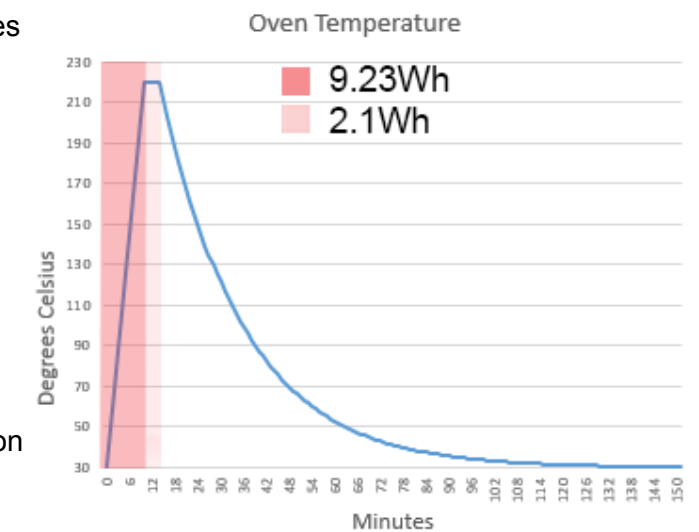


Fig. 19 - Oven temperature change

Temperature to be maintained at 30°C when outside temperature is 22°C. Knowing the volume and density of air needed heating up is simple calculating the energy required to heat it up (9800J). However, this needs to happen only once at the beginning, so to calculate the daily input of energy is much more important to know how much heat is being lost to the environment thus calculating the amount of energy needed to maintain the desired temperature.

$$\dot{Q} = kA \frac{\Delta T}{x}$$

Where k is thermal conductivity of polyurethane foam 0.003, A is the surface area of 7.6m², ΔT is 8°C and x is the insulation thickness of 0.15m.

$$\dot{Q} = 12.16J / s = 12.16W$$

Supposedly the living area heater will run all the time (24h in a day) which gives **291.84 Wh**. But it is important to take into account the heat dissipated from the oven into the cricket area. Will it affect it at all? Or it would overheat and the living area would require cooling?

Oven effect on the living area temperature

It is important to be reminded that the living area should not go above 35°C or below 25°C.

Since the heat transfer greatly depends on the temperature gradient, describing the heat transfer from the oven to the living area was made using an excel spreadsheet, to plot the variables for a period of 151minutes, which is the time it takes for the oven to heat up and then cool down - return to 30°C (equilibrium) for about two hours.

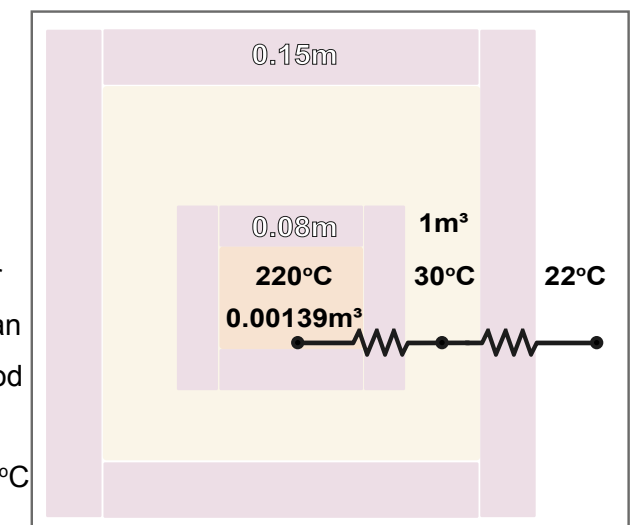


Fig. 20 - System heat resistance diagram (not to scale)

Then using the heat transfer equation from above and calculating how the heat coming from the oven minus the heat going out of the whole system affects the living area temperatures, where the farms are, if the living area heating element is switched off right when the oven is turned on.

Due to the initial dip in temperature, resulting from the heater being turned off and the rate of heat loss to the outside, which is greater than the oven contributes for that period, the farm temperature does not exceed the maximum allowed. (Appendix B, 3 - the graphs combined)

Furthermore, it could be also seen that there is no need to switch the main hearing back on at least for an hour. Therefore the energy consumption for a day is for 23h not 24h.

$$E_{farm} = 12.16W * 23h = 279.7Wh$$

Electrical Energy into Mechanical Energy

Every cylinder rotates with 1RPH (0.0167rpm; 0.001745rad/s) for the entire cricket life cycle. It disengages from the motor during harvesting. Since it is such a low speed, and the torque required is not very large, it is sensible to have 56 separate motors controlled electronically rather than one more powerful motor and a lot of mechanics to translate the rotation across all farms.

The motor of choice is an AC synchronous electromotor due to its long life, simplicity of running and longevity.

To calculate the required Power input the efficiency η , as well as the output power required, need to be known.

$$P_{in} = \frac{P_{out}}{\eta} \quad (\text{Serway, 2003})$$

$$P_{out} = \tau\omega \quad (\text{Serway, 2003})$$

Where ω is the angular velocity of 0.001745rad/s, τ is the sum of all the torques involved in N.mm. In this case the torque to overcome moment of inertia where is the angular acceleration, which for the very small angular velocity is taken as 0.05 s.

$$\tau = I\alpha \quad (\text{Serway, 2003})$$

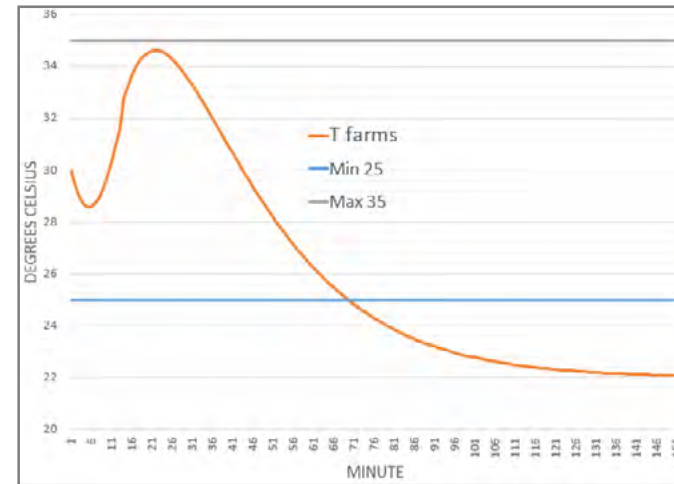


Fig. 21 - Farms area temperature change

$$I = \frac{mr^2}{2} \quad (\text{Serway, 2003})$$

Where m is the mass rotating which is 1kg at the beginning and 2kg before harvesting, (see Appendix B, 4.). r is the mass radius, which is constant 0.1m.

There are also friction torques at the both end of the rotating mass where there are two ball bearings. They share the total load, but have different sizes. The friction torques can be found:

$$M_r = Ff \left(\frac{d}{2} \right) \quad (\text{www.roytech.co.uk})$$

Where f is friction coefficient of the bearings 0.003, d is the inner diameter 15mm for the smaller and 50mm for the bigger bearing. F is the load which is half the load of the whole cylinder:

$$F_1 = F_2 = \frac{mg}{2}$$

It could be seen that the load depends on the mass, consecutively the friction torque at the two ball bearing depends on mass, same for torque to overcome moment of inertia. Once again this was all calculated in a spreadsheet and the changing load taken was into account - see fig.22.

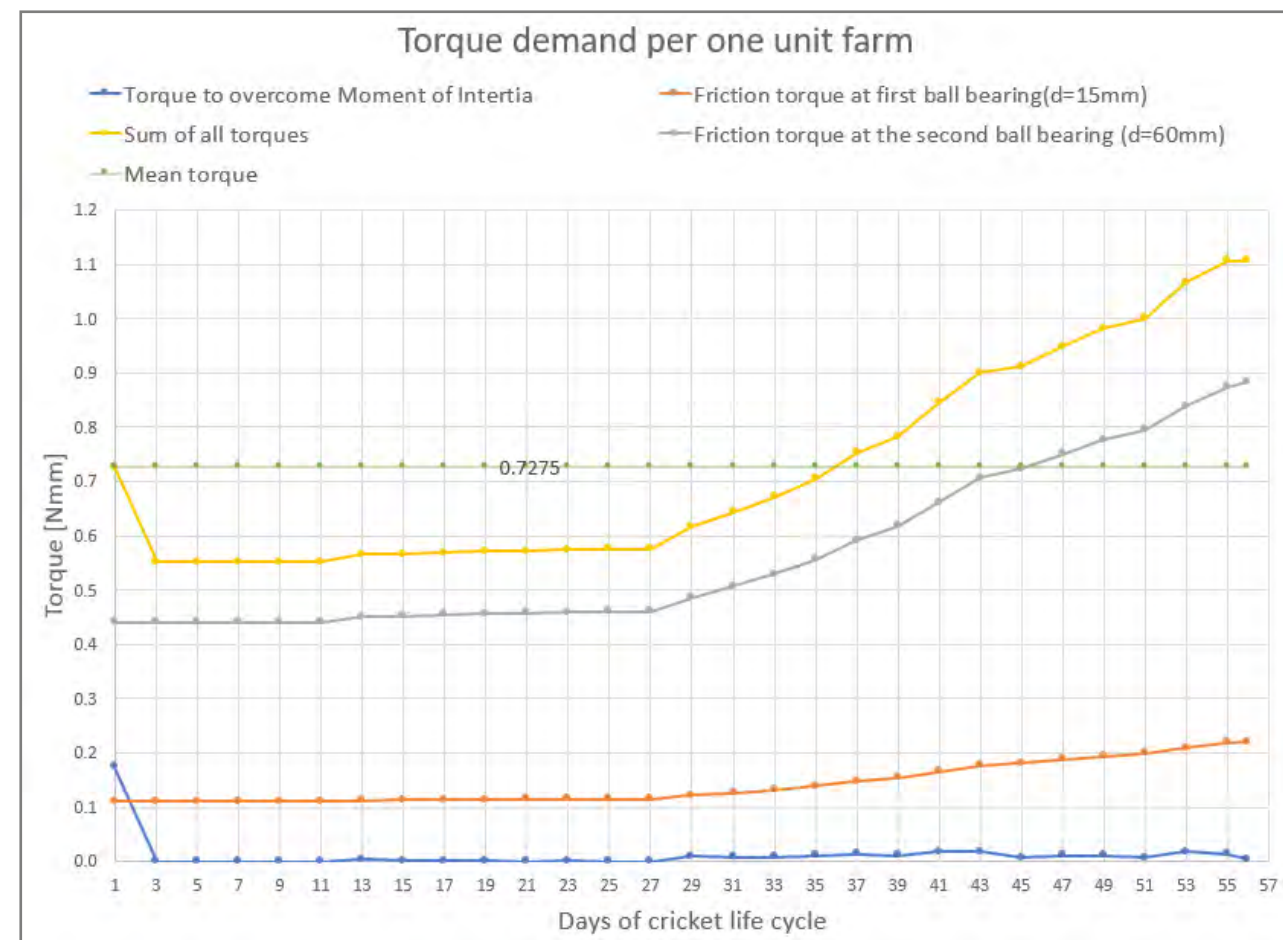


Fig. 22 - Torque demand change depending on cricket growth

There are 56 farms, each of them on a unique day, so it could be concluded that the mean torque value multiplied by 56 is the torque required per day.

$$0.7275Nmm * 56 = 40.74Nmm$$

Plugging it into the power output equation this gives: 0.001745rad/s

$$P_{out} = \tau\omega = 40.7Nmm * 0.001745rad / s$$

$$P_{out} = 0.071mW$$

Gearing efficiency

Looking at a conservative case, a 250rpm motor needs to be geared down 15 000 times to provide 1 rotation per hour. Maximum gear ratio of a worm gear is 75, which means that 3 gears will be required e.g. 25 x 25 x 24 = 15 000.

Worst case scenario - taking the minimum efficiency of a gear 0.2 to the power of three would give a motor efficiency of 0.008

$$0.0711/0.008 \text{ } 8.9mW \times 24h = 213mWh = 0.2Wh$$

$$P_{in} = \frac{P_{out}}{\eta} = \frac{0.071mW}{0.008} = 8.9mW$$

Taking that the motors rotate all the time:

$$E_{mot} = 8.9mW * 24h = 0.213Wh$$

Total Energy to run

Total electrical energy is

$$E_{el} = E_{boiler} + E_{farm} + E_{oven} + E_{mot} + E_{oth}$$

Additional energy will be required that has not been taken in into consideration in this report
- heat recovery ventilation, vending mechanisms, user interface touch screen, lights and etc.
Conservatively it is approximated to half the calculated energy giving daily electricity consumption of:

$$E_{el} = 298.47Wh + \frac{298.47Wh}{2} = 447.7Wh$$

For one year:

$$447.7Wh * 365 = 163.4kWh$$

It will be easier to add this to the feed if it is converted to pounds.

Average price for a kWh as of today is 12p (ukpower.co.uk) giving **£19.6** per year, **5p a day**.

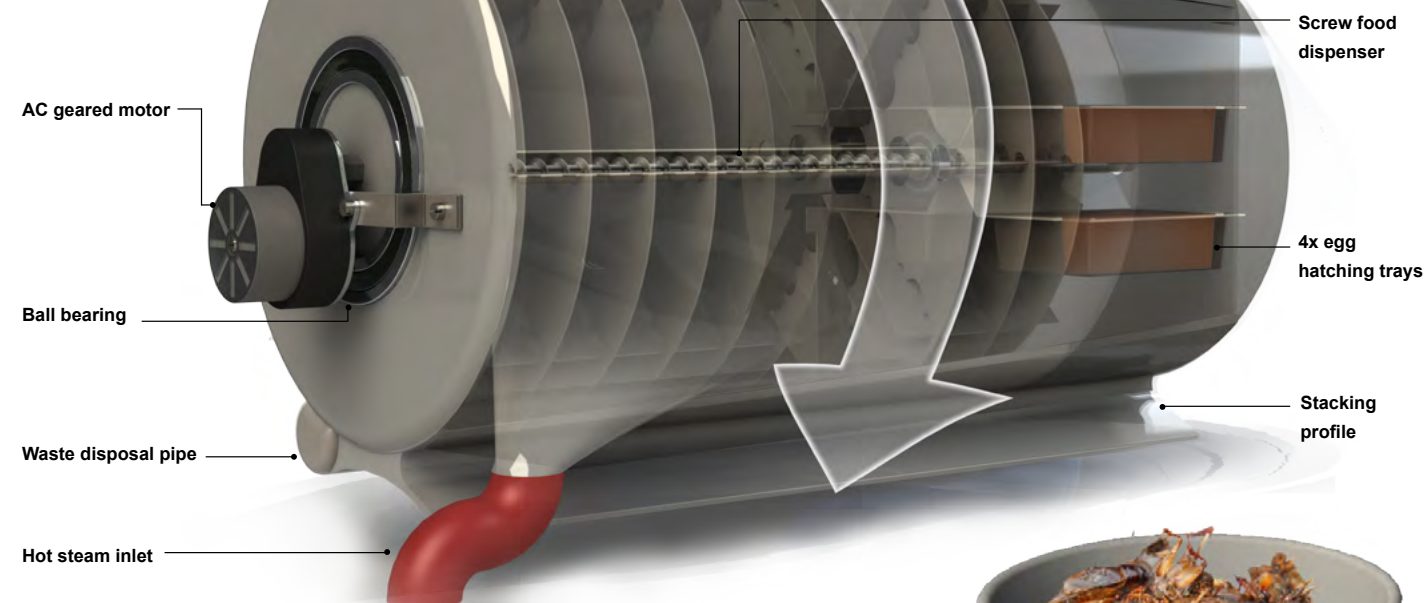
From feed calculation it can be concluded that to harvest 1 kg of crickets a day, 0.5kg when cooked (see appendix), it requires:

40p + 5p = 45p cost to run the machine per day, excluding servicing and maintenance, which technically should not happen often at all.

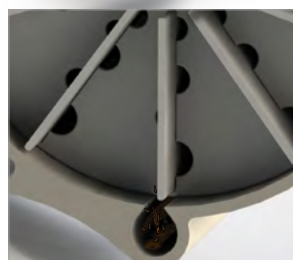
Deliver

Poster game	107
Final prototype	109
Manufacturing and Assembly drawings	120
Last words	135

At this stage I am pretty confident with the technicalities of my cricket farm unit, and have tested it with the users - crickets. Human users like the product. Just have not experimented much with machine interface and interaction - did not concentrate on its design that much.



Cricket feed runs through a pipe in the middle.



Constant rotation disposes of waste at all times. It is collected in a pipe and sucked into the bin.



Four trays with gravel and a mesh on top to provide safe egg laying and hatching.



Crunchy and protein rich snack with a range of flavours.

Poster game

We had pin-up with feedback a week before hand in. The first one below is what i submitted. Everyone said it was too much.. so I got rid of the unit farm.. I have to have it built after all :)

Putting a person in without looking uncool ws pretty tough.. I am not sure I managed perfectly, but it's alright :)

criCup

Roasted crickets vending machine

56 cricket farms, carefully designed for maximum efficiency.



- * Current methods of meeting the food demand are simply unsustainable.
- * Insects are proven to be rich in nutrients, efficient and environmentally friendly source of food.
- * The designed product produces, processes and dispenses 1kg of crickets a day in the form of a healthy snack in a variety of flavours.
- * criCup helps normalise eating insects by being available in public spaces and social contexts.

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- * Current methods of meeting the food demand are simply unsustainable.
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- * criCup helps normalise eating insects by being available in public spaces and social contexts.



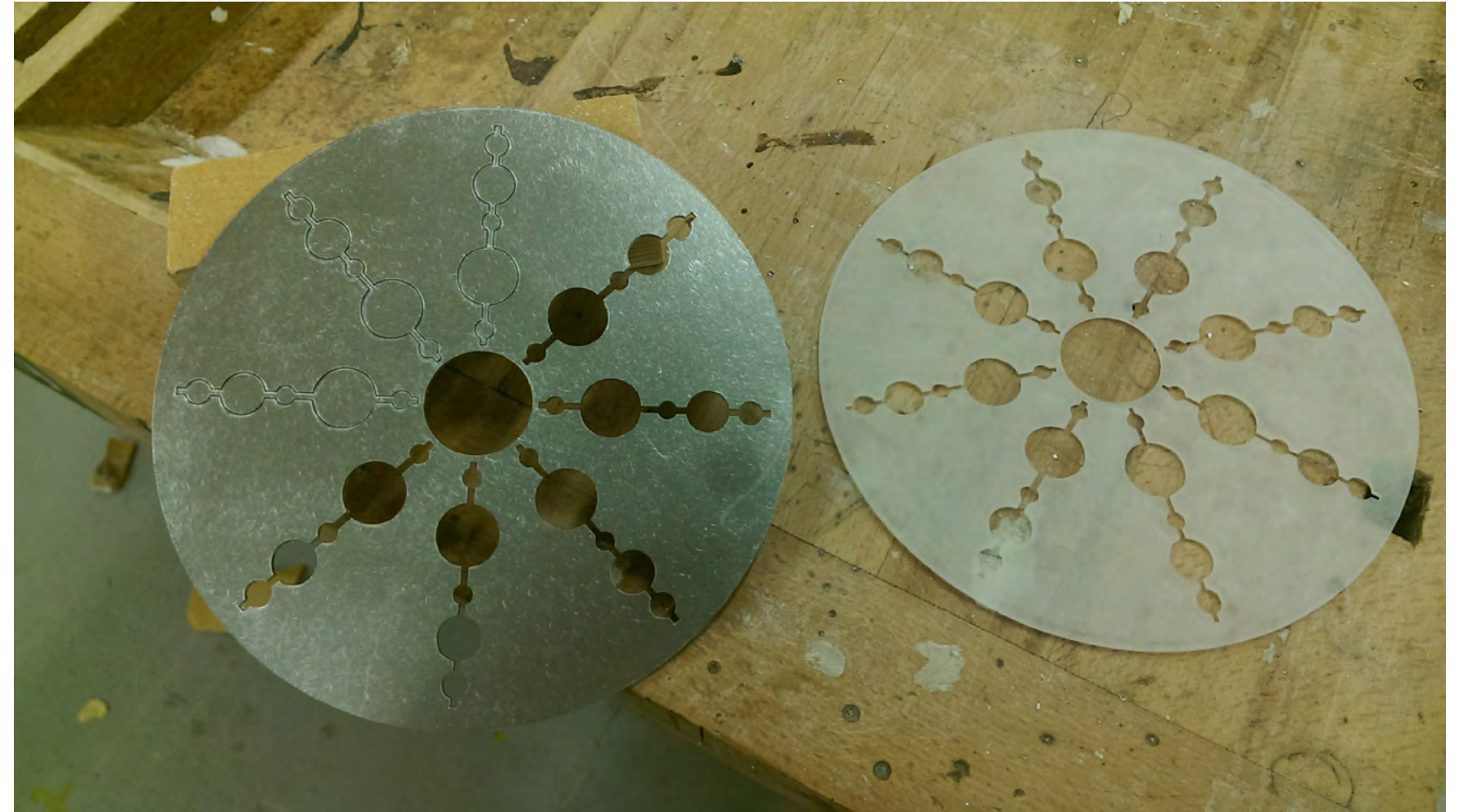
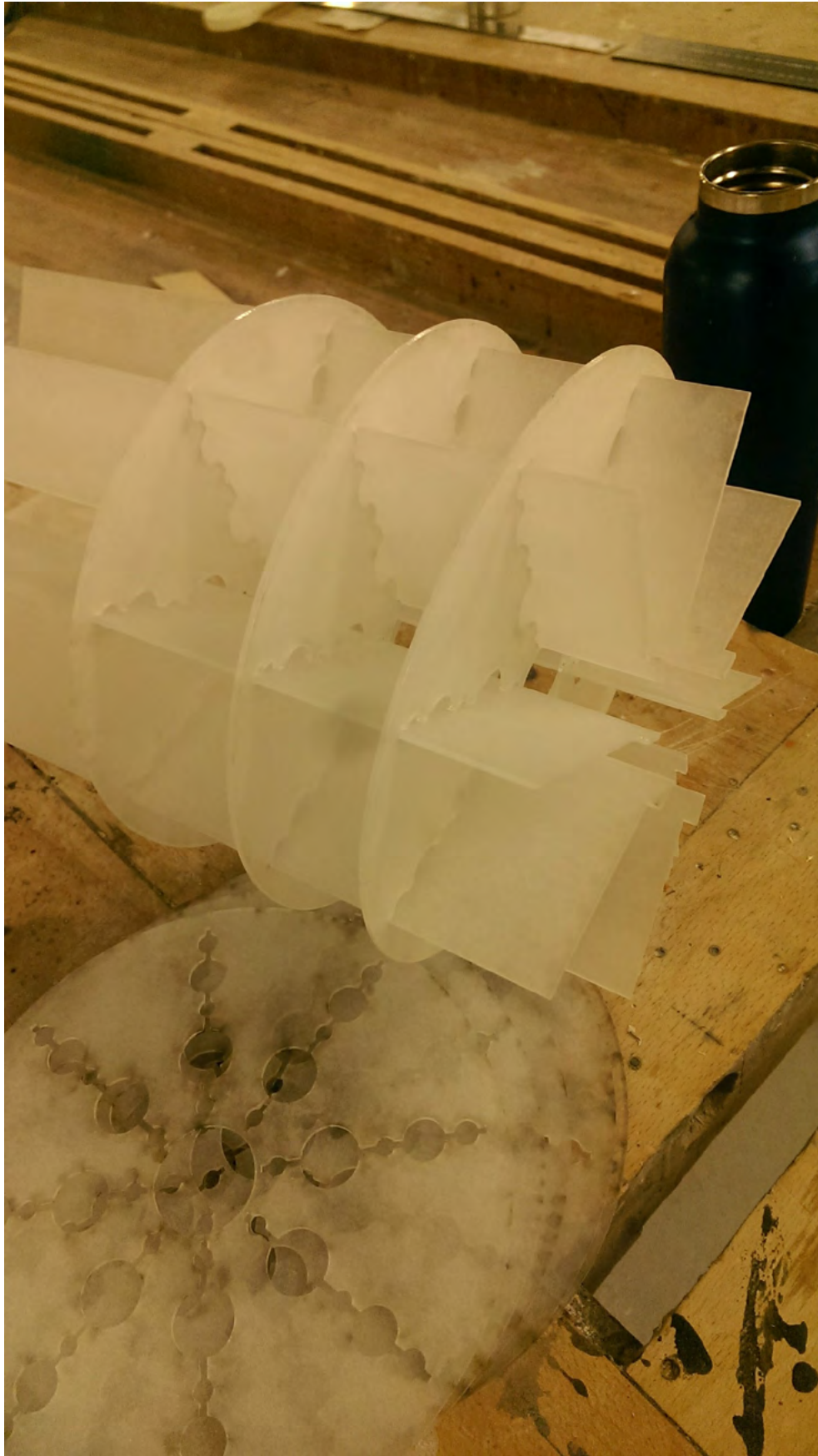
Posters arrived! I can see the end coming!

Final prototype ...below

But now let me tell you about what I built.

Firstly, I wanted to build a scaled model of the whole vending machine, nice and sleek, and a 1:1 working prototype of a single farm unit next to it.

Realised it was too ambitious. Decided to build the working unit and my plan was to put live crickets in it.

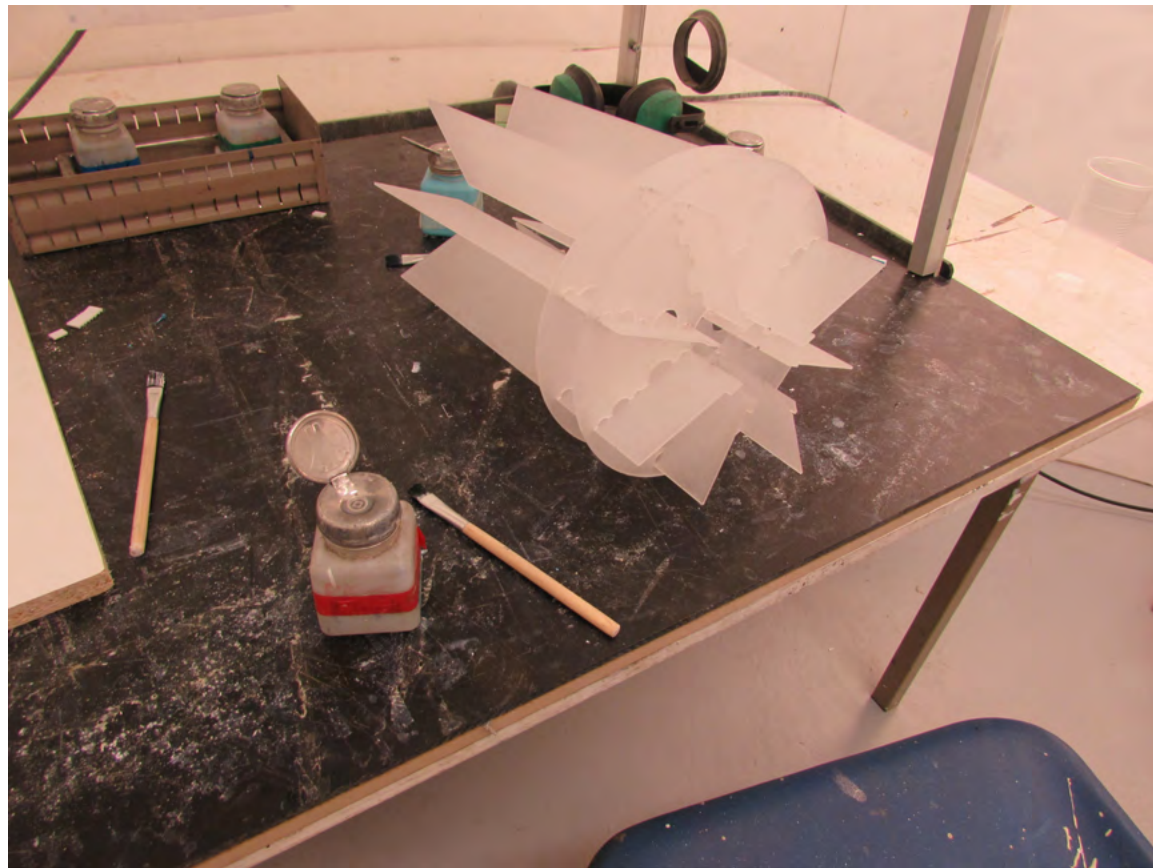


To Aluminium or not to Aluminium

Not only did I want to put crickets in it, I want to make it out of aluminium sheet. Thankfully the workshop guys advised me on cutting it out of acrylic, which was a very good call, since I had to recut it quite a few times.

Before cutting any of the main parts I sanded the acrylic for quite a while to make it comfortable for potential inhabitants. They need grip.

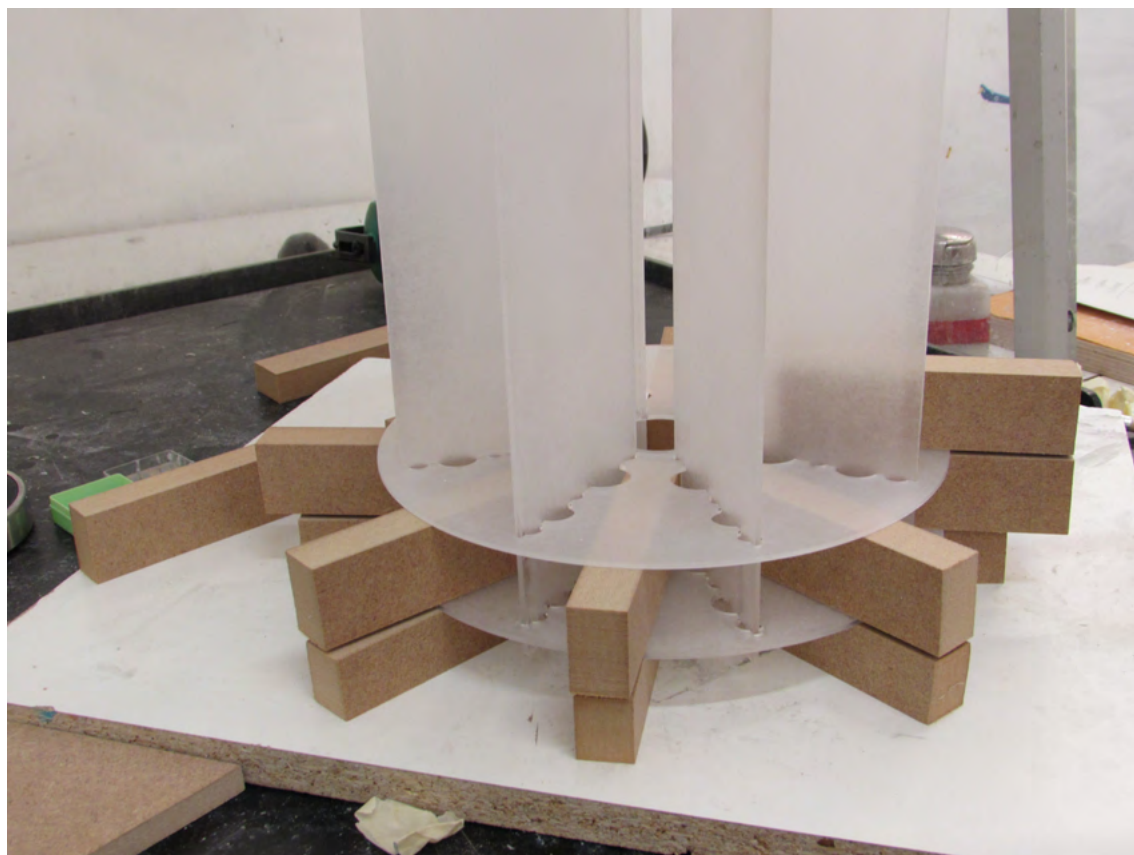
I tried a metal finish spray to make the acrylic look like aluminium. It did seem pretty good and everyone I asked said they like it, but part of me still wanted to put crickets in and knowing the spray was toxic made me decide against it.



Failure #1

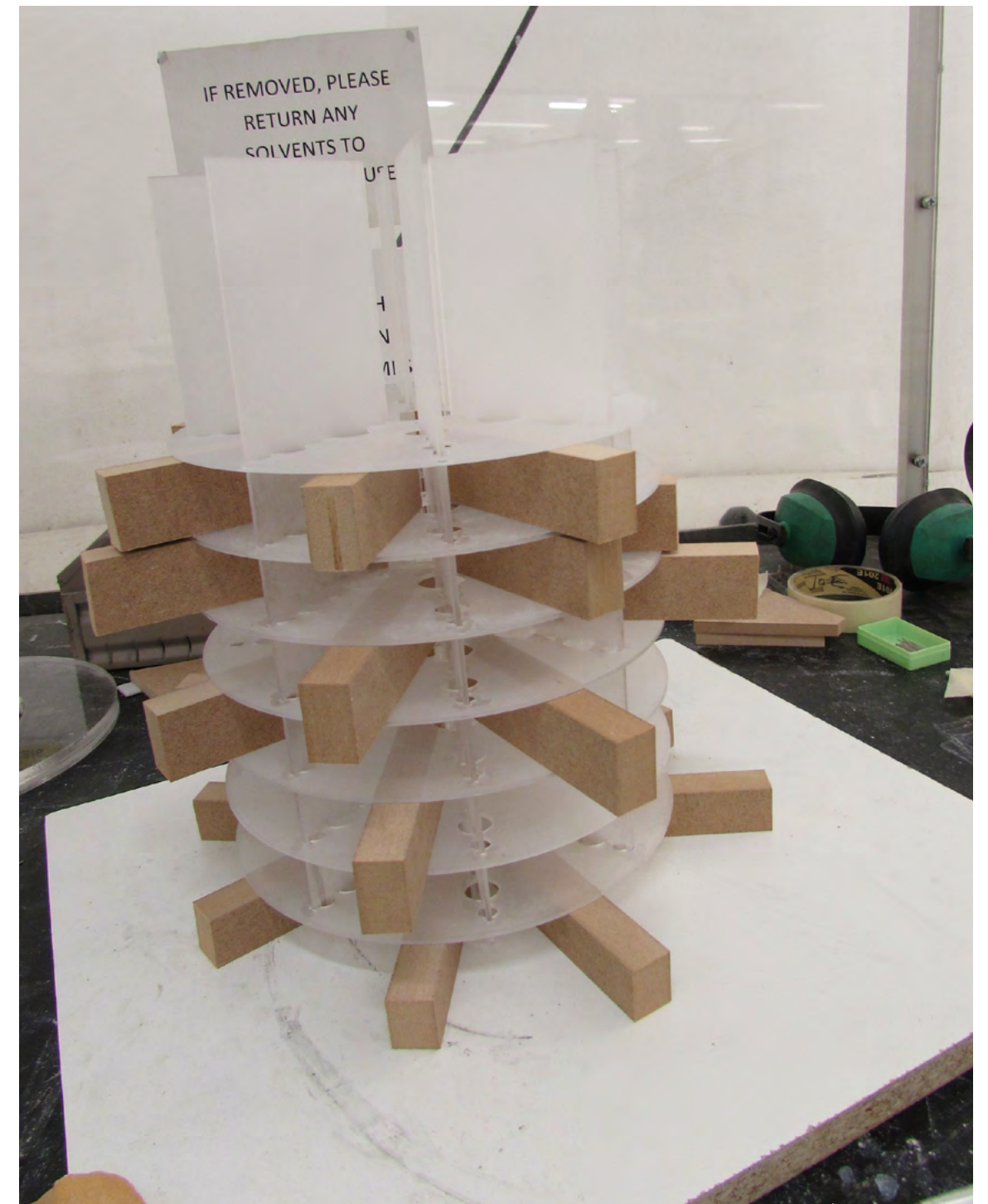
I'm not going to lie and pretend I did a good job the first time I tried to glue everything together. I knew it was going to be difficult to align so many moving parts. I had the bad memory from the MDF prototype. And in the rush I glued it really badly. I threw it away before I could take some pictures of my failure :D

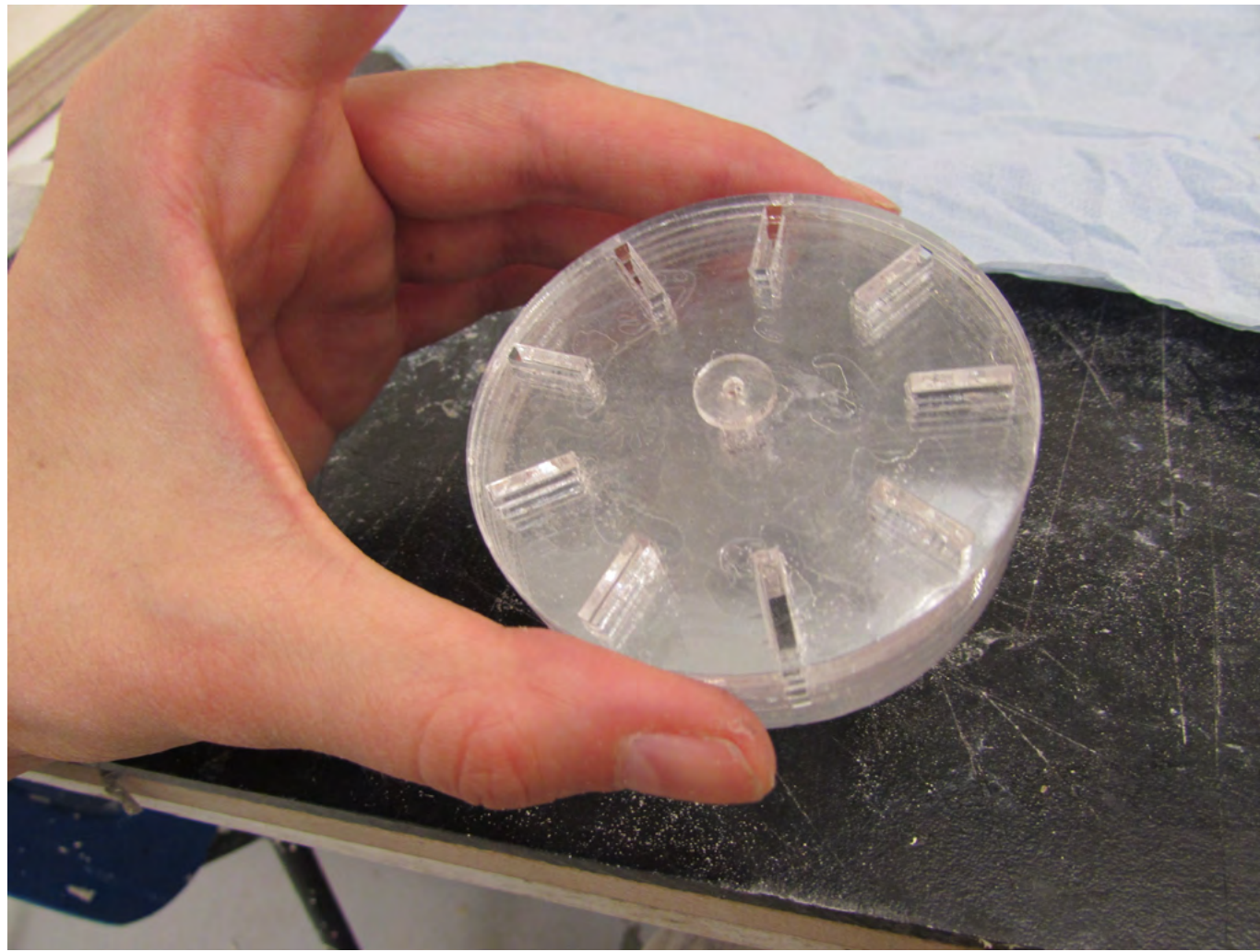
Susanne saves the day



Thankfully, Susanne and her model making expertise and willingness to help were around.

With some careful aligning, loads of spacers and jigs the main components were glued together perfectly square. :)





Failure #2,3

The part on the left consists of 6 layers 3mm Acrylic. 2 layers to hold the motor in place and 4 to hold the square elements.

It is important that it is perfectly lined up, since it transmits rotating motion.

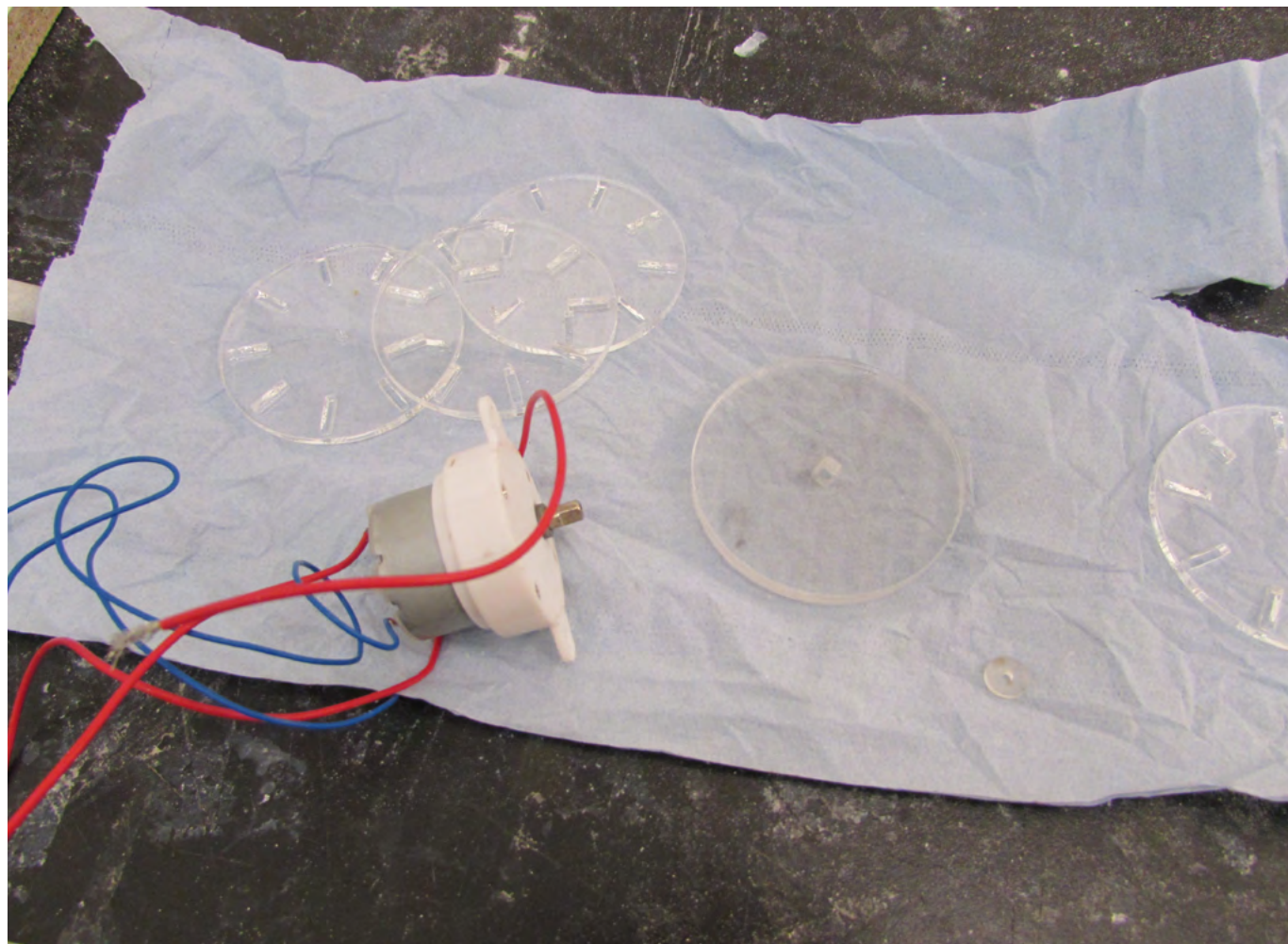
1st time died with the first badly glued prototype.

Then I made it again.. only to realise at the end of the day that I have lasercut it with 9 instead of 8 holes.

Made it again. 8 holes. Glued it precisely.

Then I had to put it on top of the perfectly aligned living area and Susanne gave the smart idea to glue them layer by layer. Really smart.. and I had to cut it again.

A lot of wasted material, time and money, but hopefully the lesson is learned.





Food pipe

Another challenging part was the feeding tube. Opening up an aluminium tube was quite a bit of a task. Thankfully Christ, the metal god, was around :)

Bashing it in various ways made it lose a bit the perfect circular shape. Some more bashing to get that back on track aaaaaand a lot of sanding to make it go through one of the bearings okay.

Shapeways 3d printed screw arrive looking good. Few difficulties gluing it together, but at the end it was worth it :)



Egg trays

Any Star Wars Fans there?

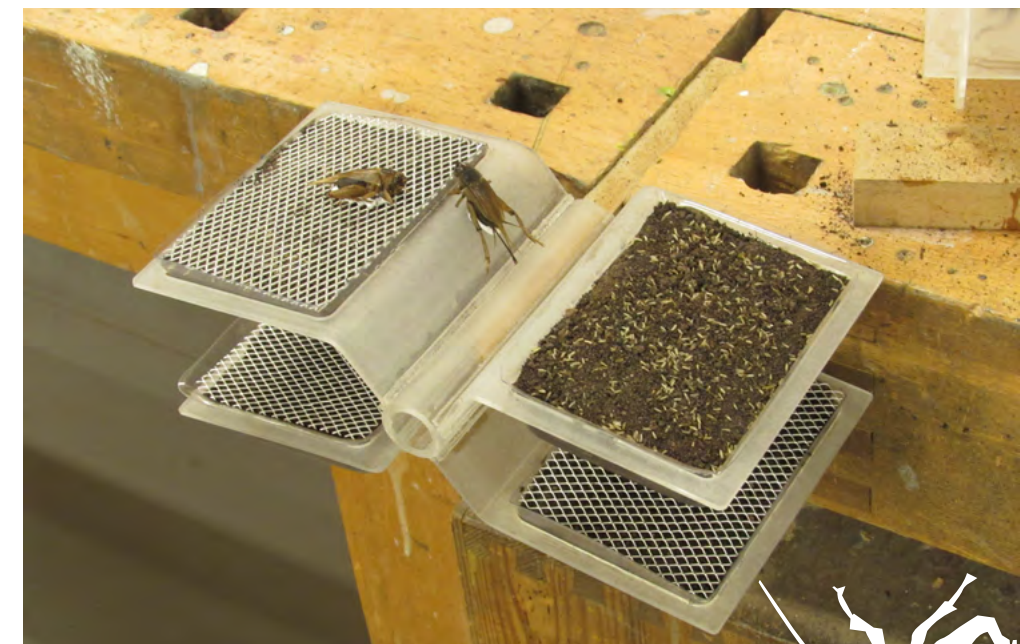
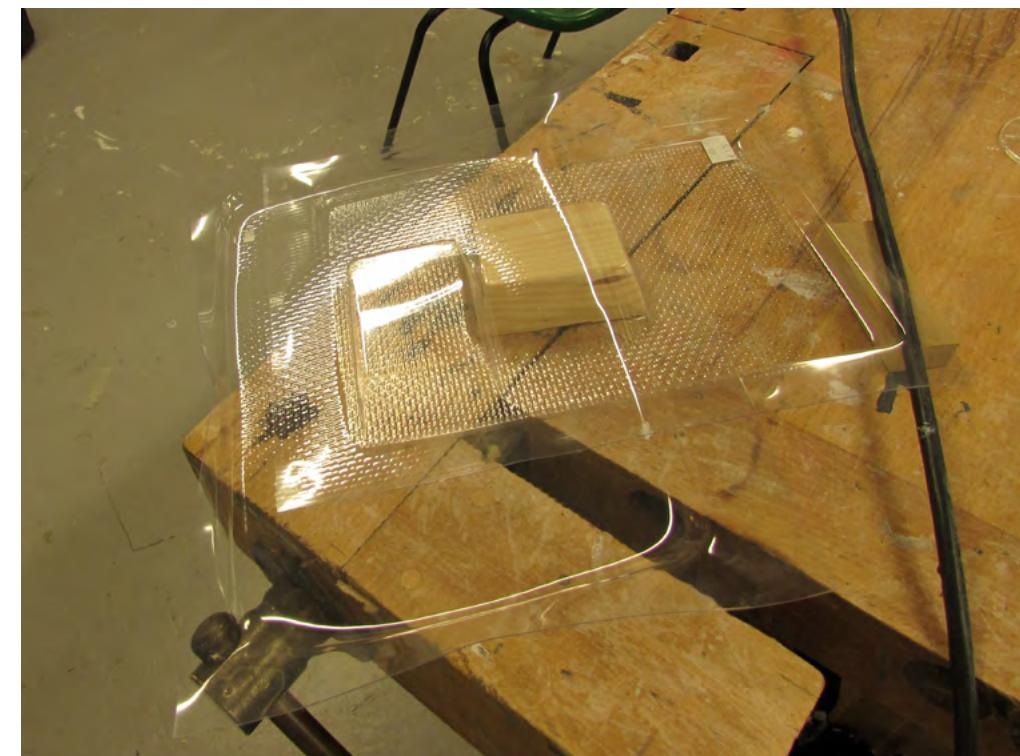
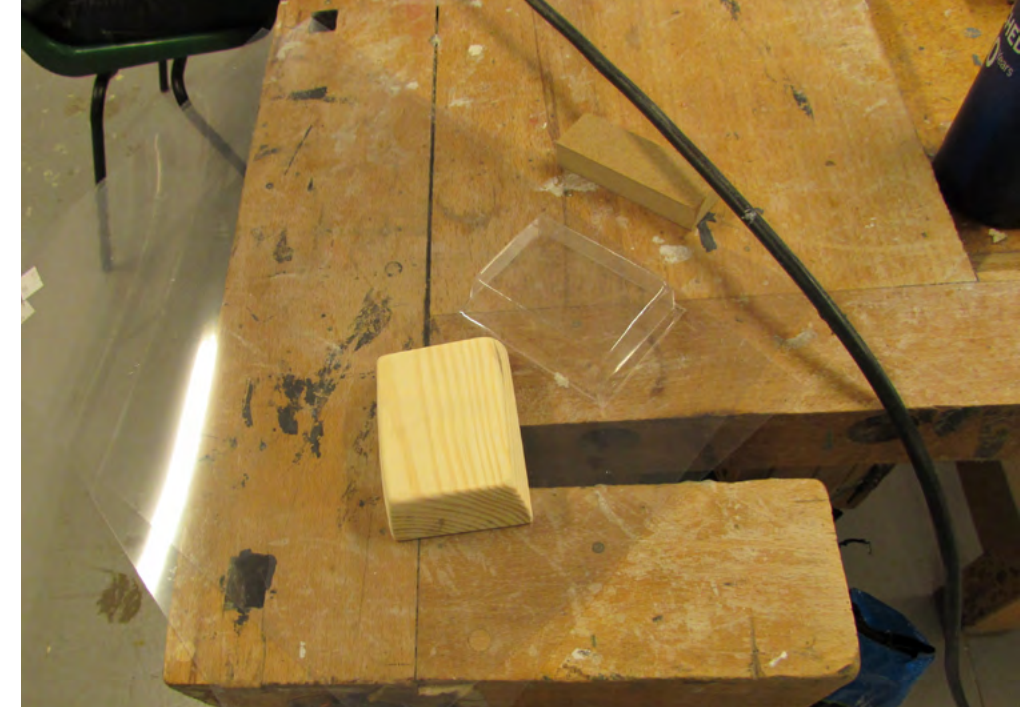
4 egg trays

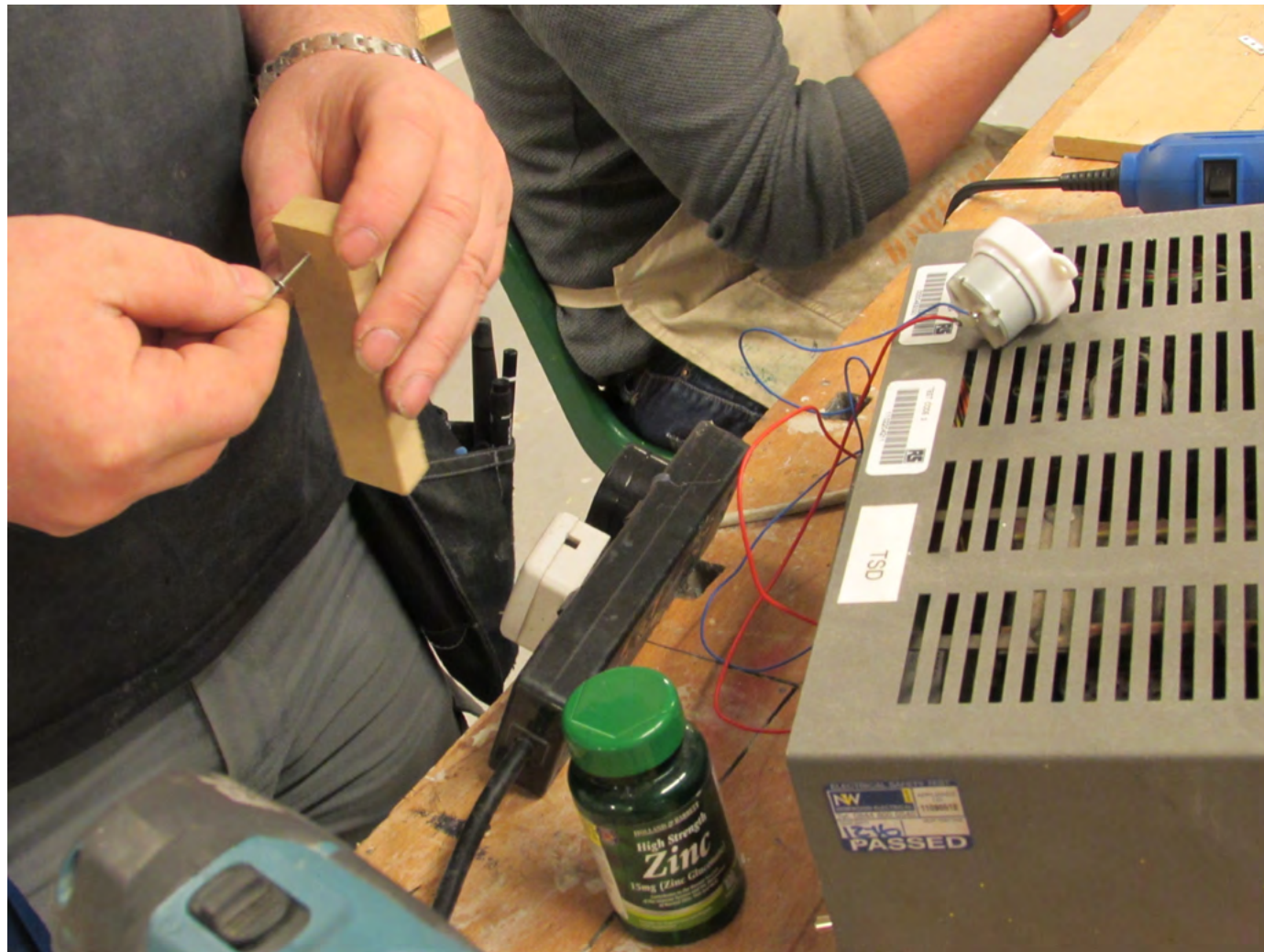
Vacuumforming.

3 aluminium meshes. 1 less so that people can see my carefully collected cricket eggs! :))

Gluing thin acrylic to shin acrylic tube was quite tricky. Some thin acrylic strips were put for support.

Oh, and I forgot to mention. I decided against live crickets and happened to have some in the freezer that got sprayed with hair lacquer and glued to my prtotype :)





Motor timeeeez

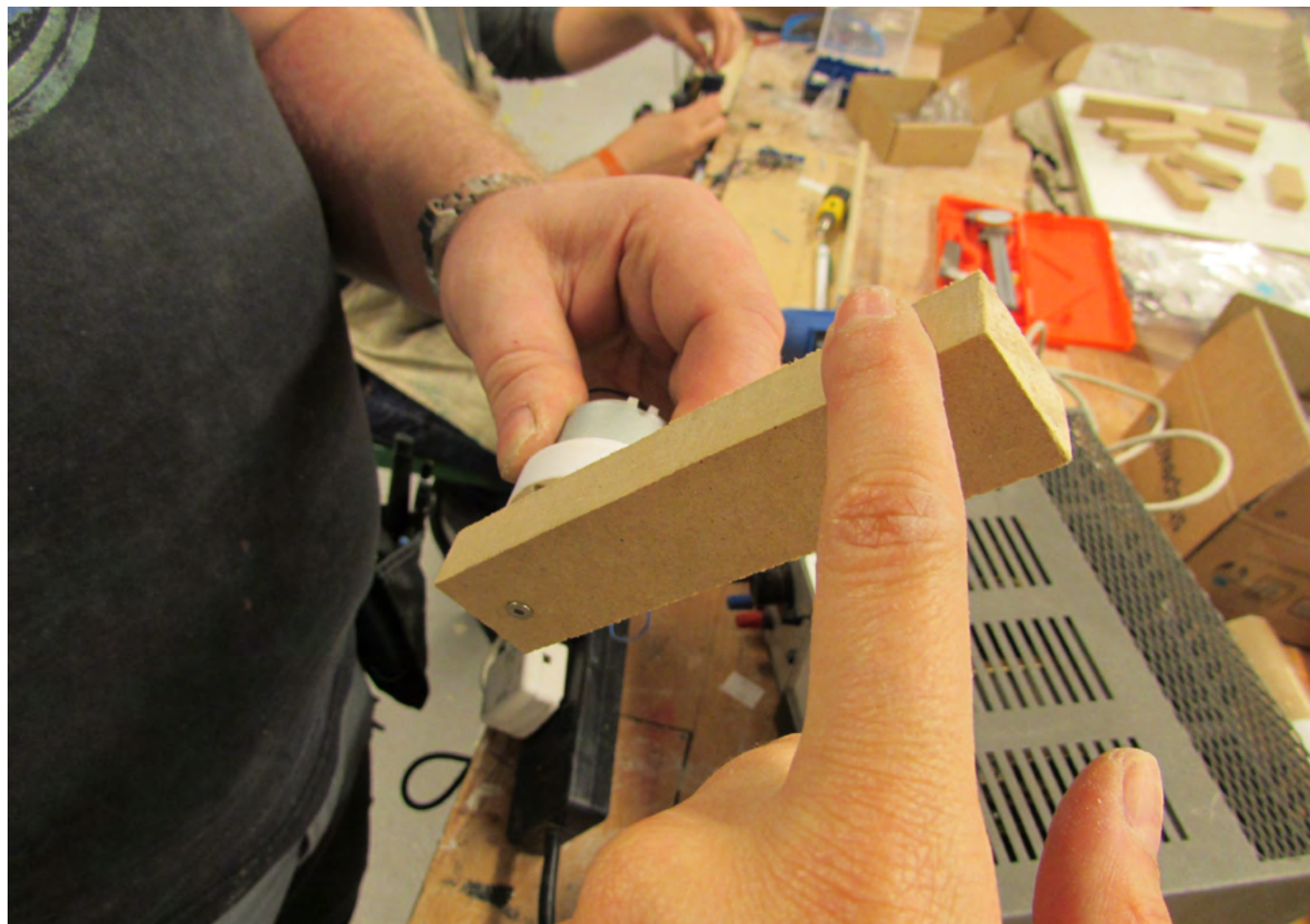
Measuring torque. All good.

I need 6V 1A power supply.

Now lets glue!

Oops, I did it again. I glued not perfectly straight...

Thankfully Joe came helping, hammering here and there and there some unforeseen consequences...





Here is my power supply.



And here is my handle. What, what?

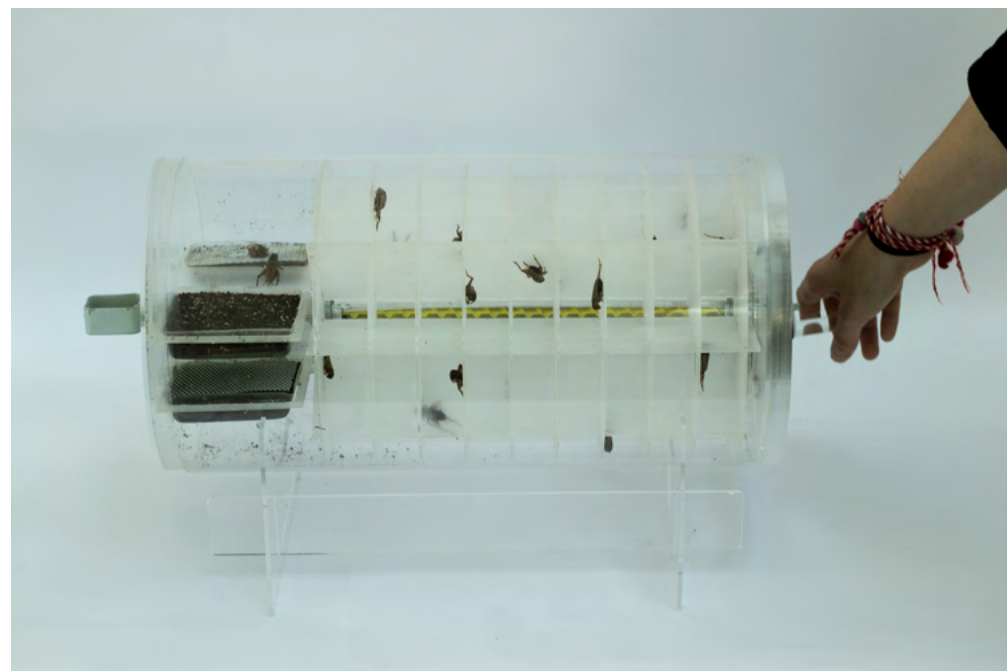
Oh yeah, you can see my broken motor too :D

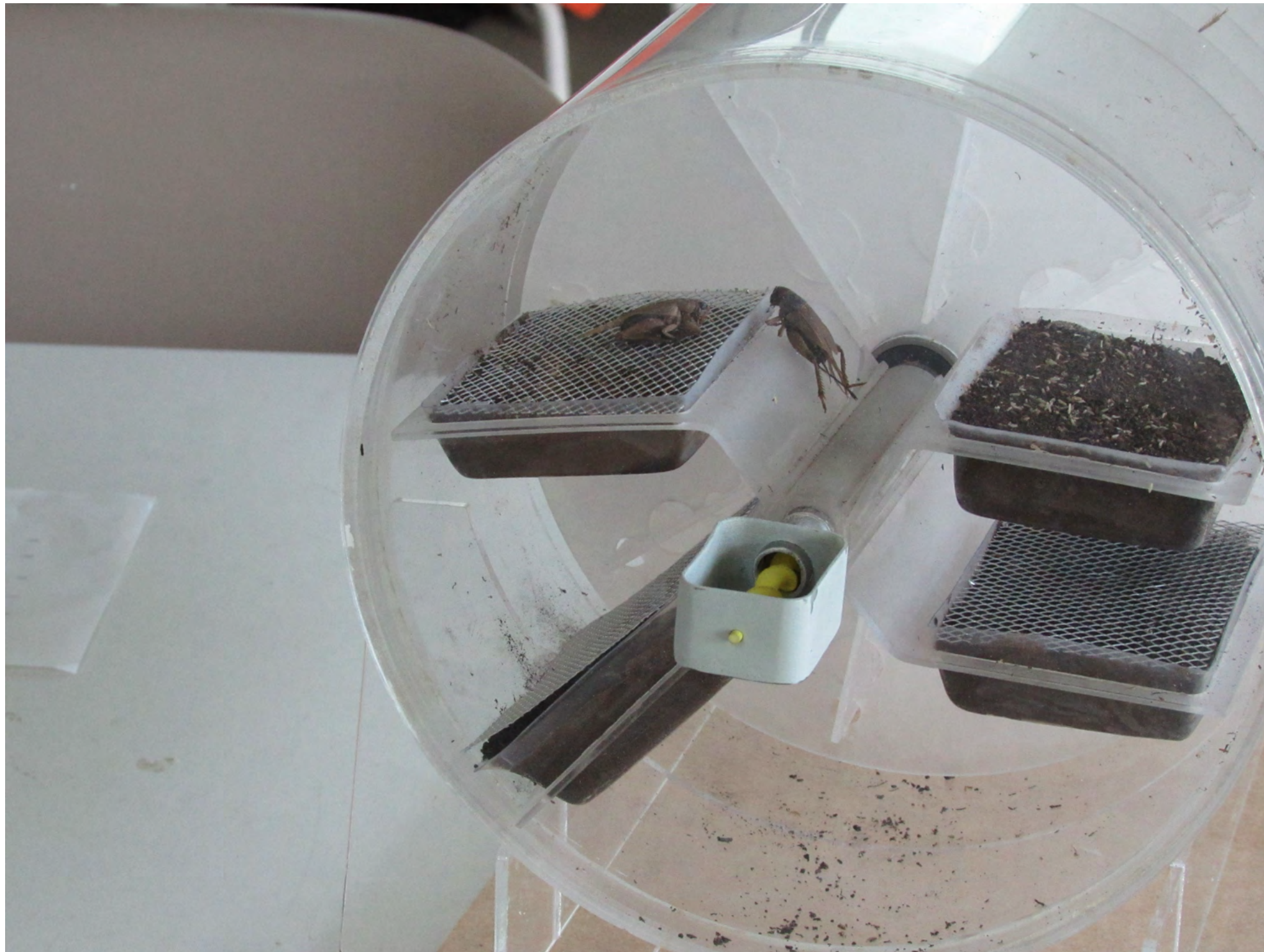
I ordered a new one, but unfortunately this happened Friday before submission, so I made a handle.

The motor will be back in business for degree show :)



Ooops continues.





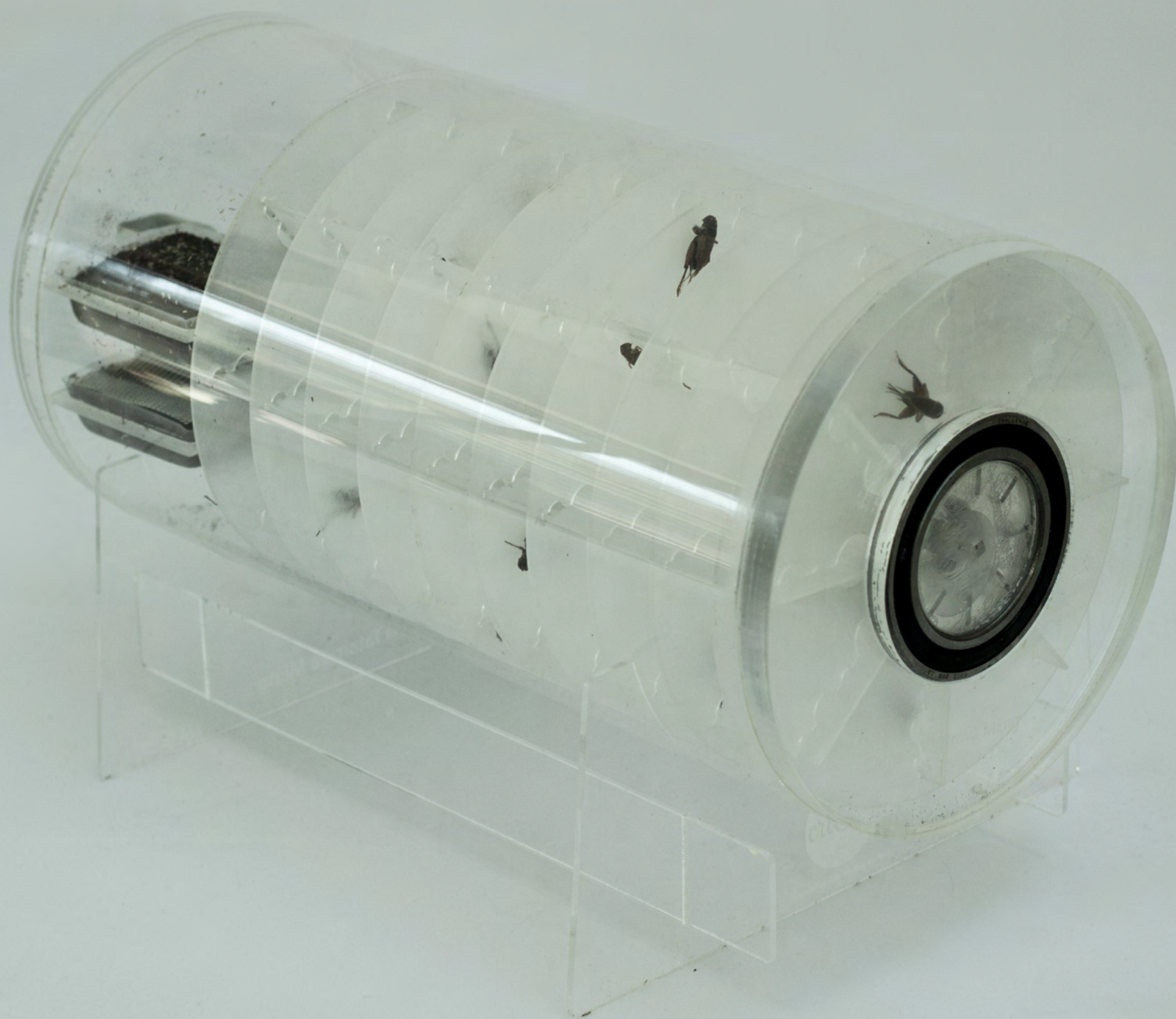
And then... this happened :/

At least I managed to get some pictures beforehand.

I did not see it happen, I did not hear it happen. So I do not know what caused one of the trays braking.

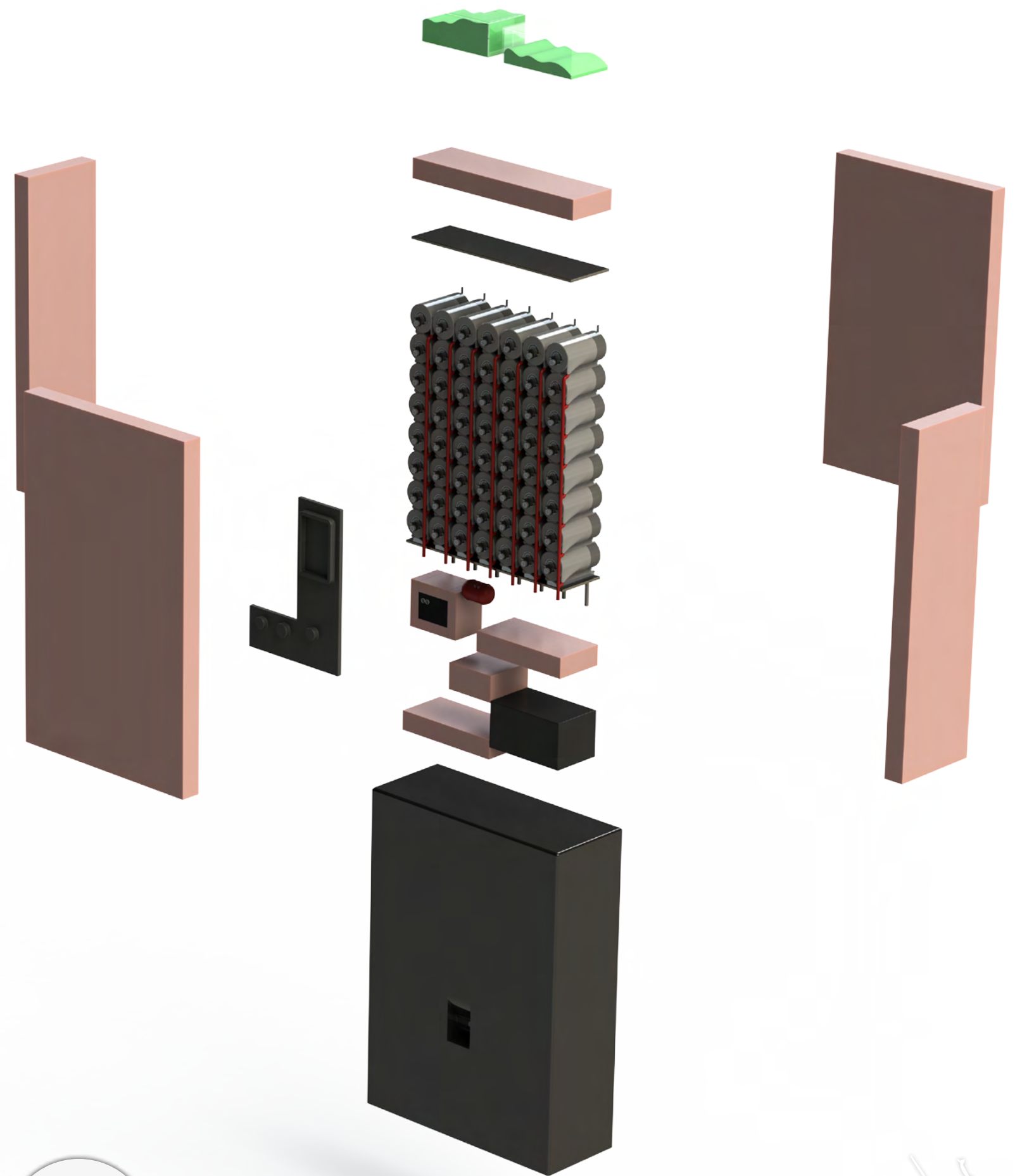
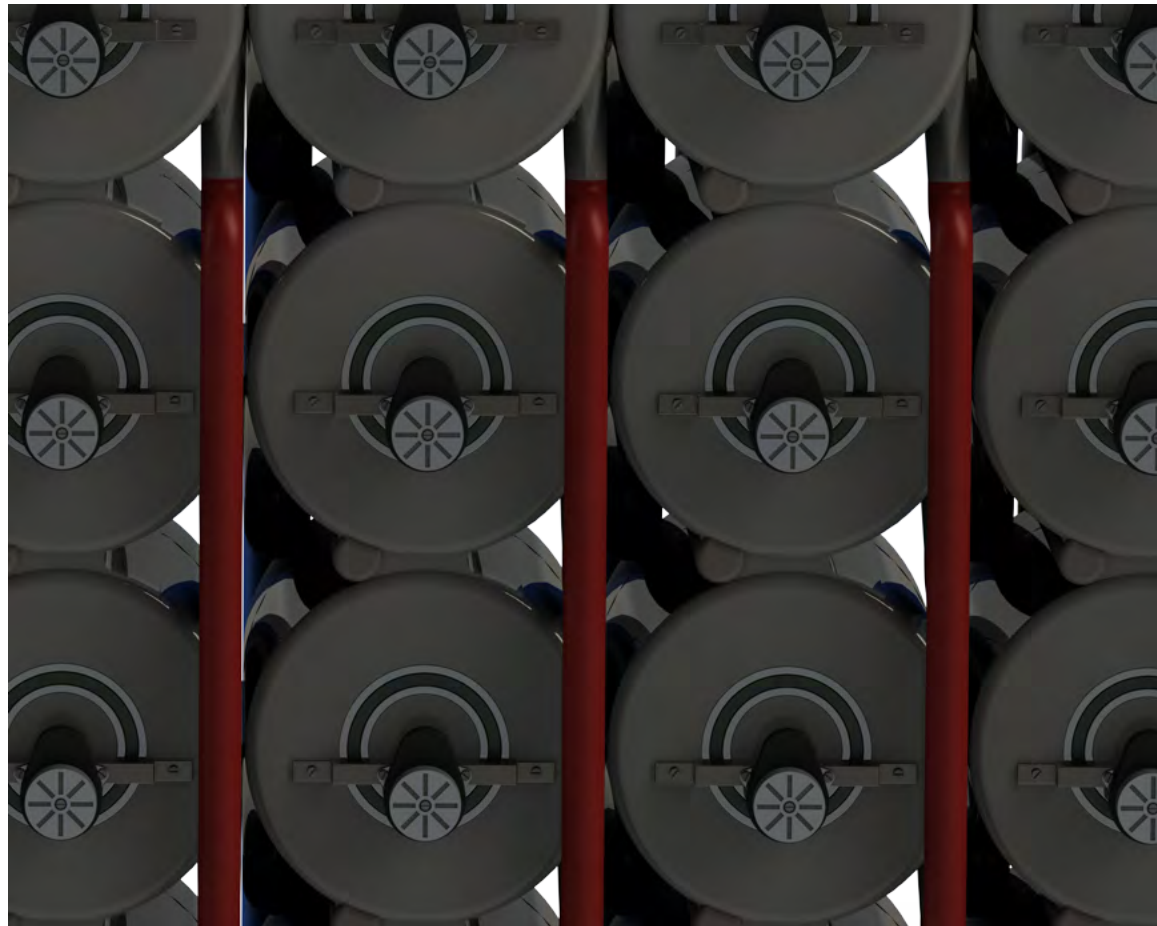
And unfortunately, it is pretty difficult to repair - everything is solidly glued together.

Will brainstorm some solution for degree show.

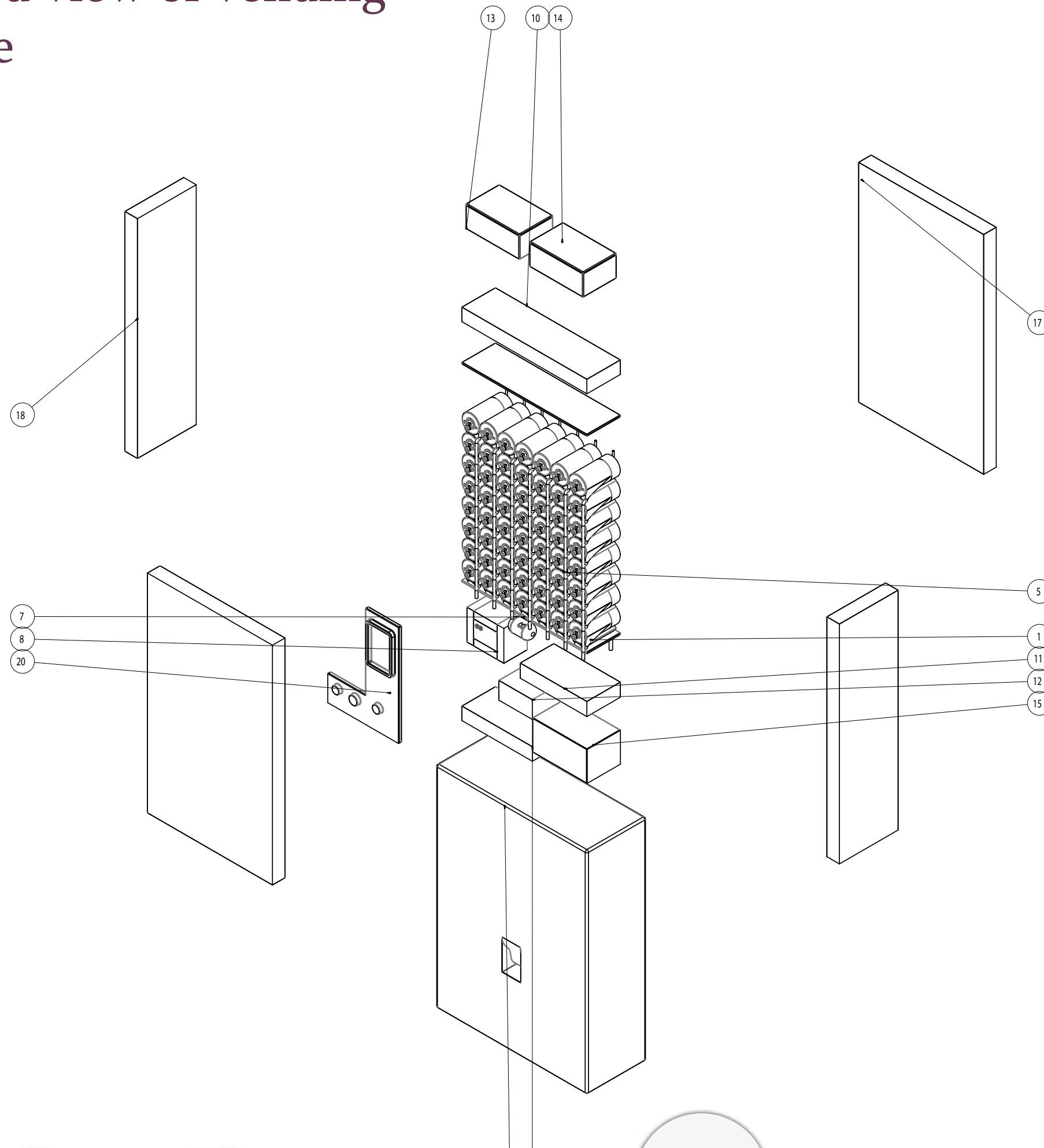




Manufacturing and Assembly drawings

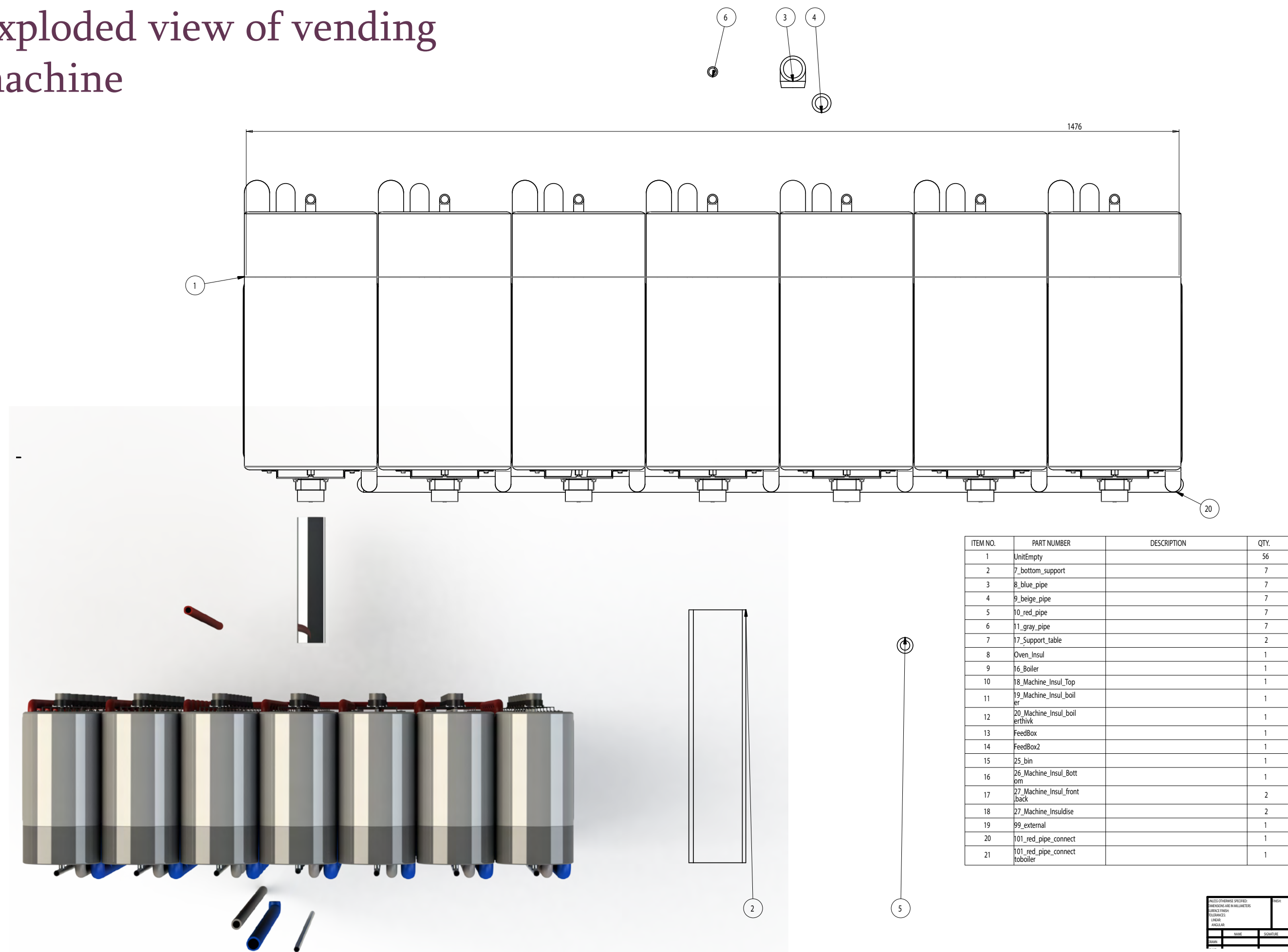


Exploded view of vending machine



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	UnitEmpty		56
2	7_bottom_support		7
3	8_blue_pipe		7
4	9_beige_pipe		7
5	10_red_pipe		7
6	11_gray_pipe		7
7	17_Support_table		2
8	Oven_Insul		1
9	16_Boiler		1
10	18_Machine_Insul_Top		1
11	19_Machine_Insul_boiler		1
12	20_Machine_Insul_boilerthvsk		1
13	FeedBox		1
14	FeedBox2		1
15	25_bin		1
16	26_Machine_Insul_Bottom		1
17	27_Machine_Insul_frontback		2
18	27_Machine_Insuldise		2
19	99_external		1
20	31_dispens		1

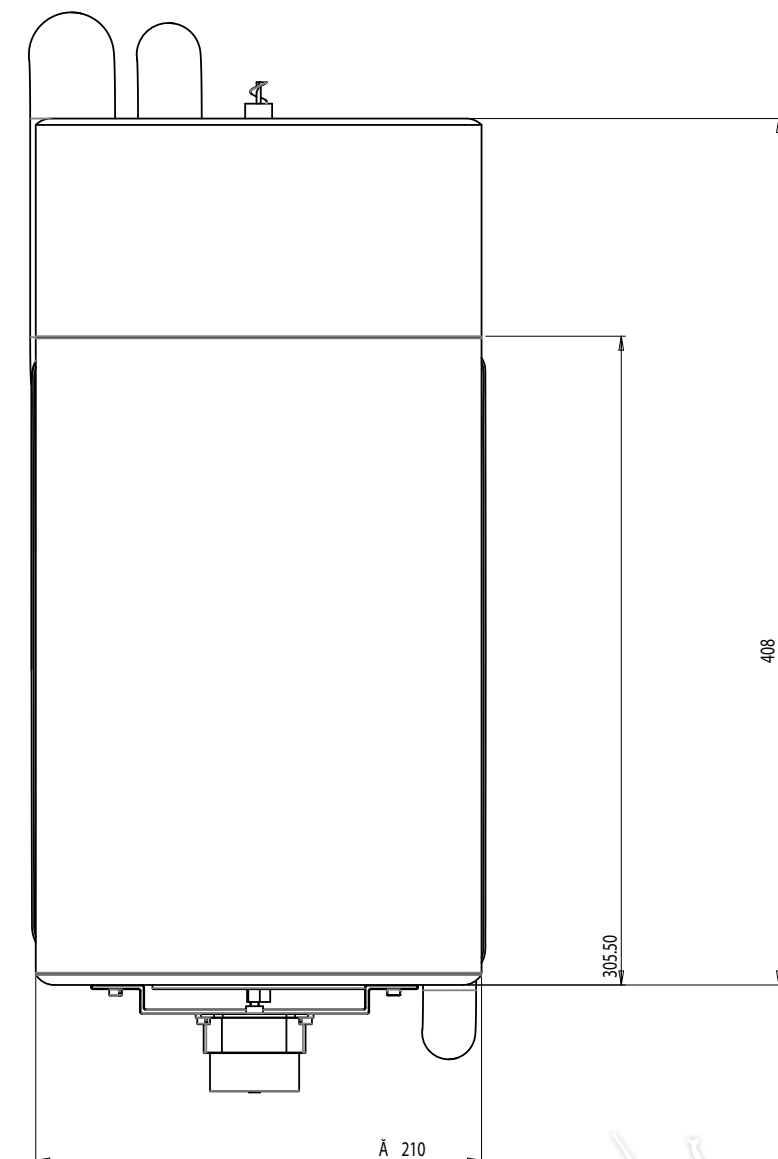
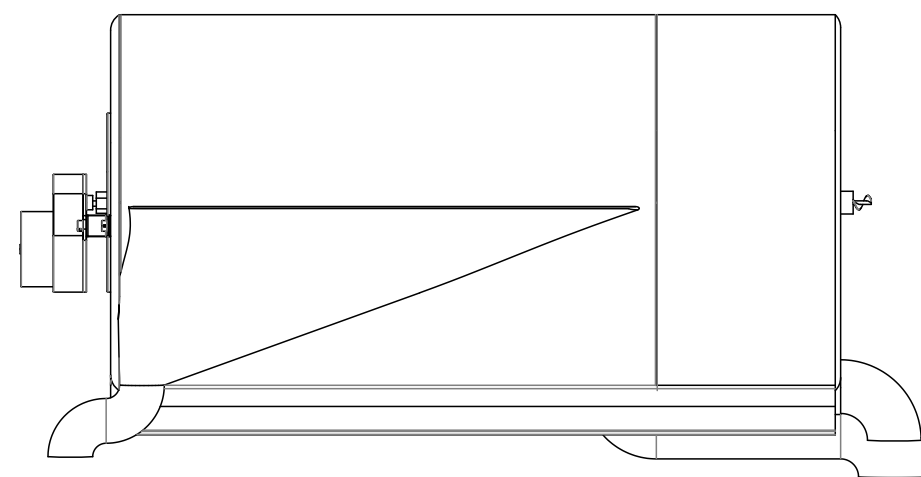
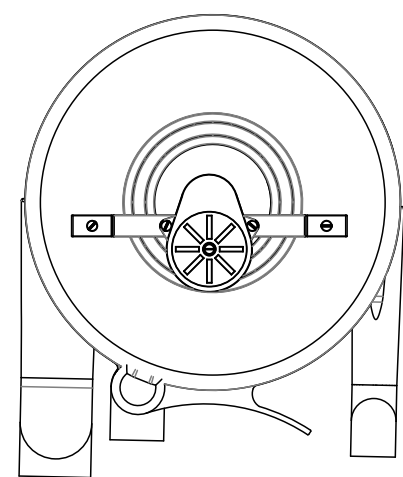
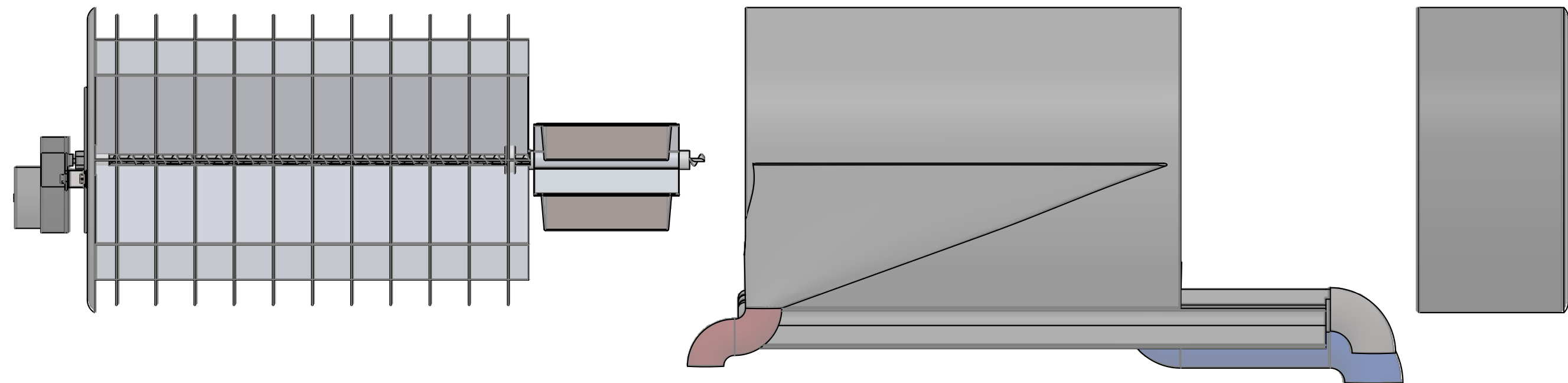
Exploded view of vending machine



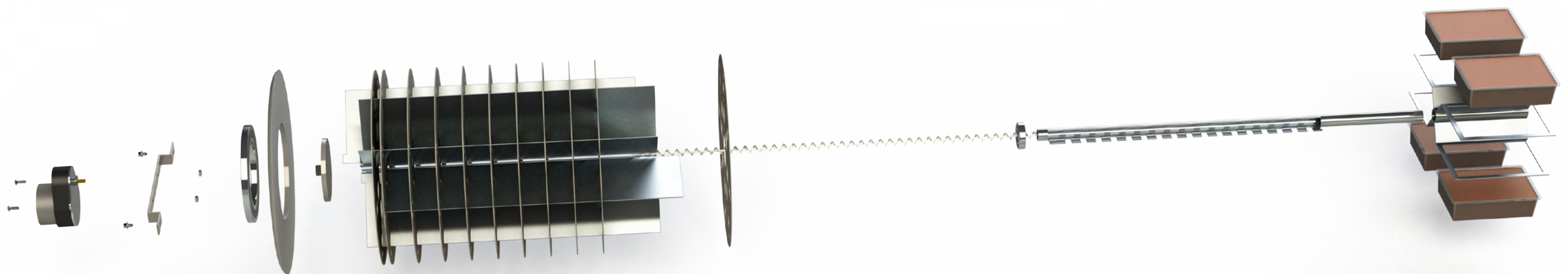
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	UnitEmpty		56
2	7_bottom_support		7
3	8_blue_pipe		7
4	9_beige_pipe		7
5	10_red_pipe		7
6	11_gray_pipe		7
7	17_Support_table		2
8	Oven_Insul		1
9	16_Boiler		1
10	18_Machine_Insul_Top		1
11	19_Machine_Insul_boiler		1
12	20_Machine_Insul_boilerthivk		1
13	FeedBox		1
14	FeedBox2		1
15	25_bin		1
16	26_Machine_Insul_Bottom		1
17	27_Machine_Insul_frontback		2
18	27_Machine_Insuldise		2
19	99_external		1
20	101_red_pipe_connect		1
21	101_red_pipe_connecttoboiler		1

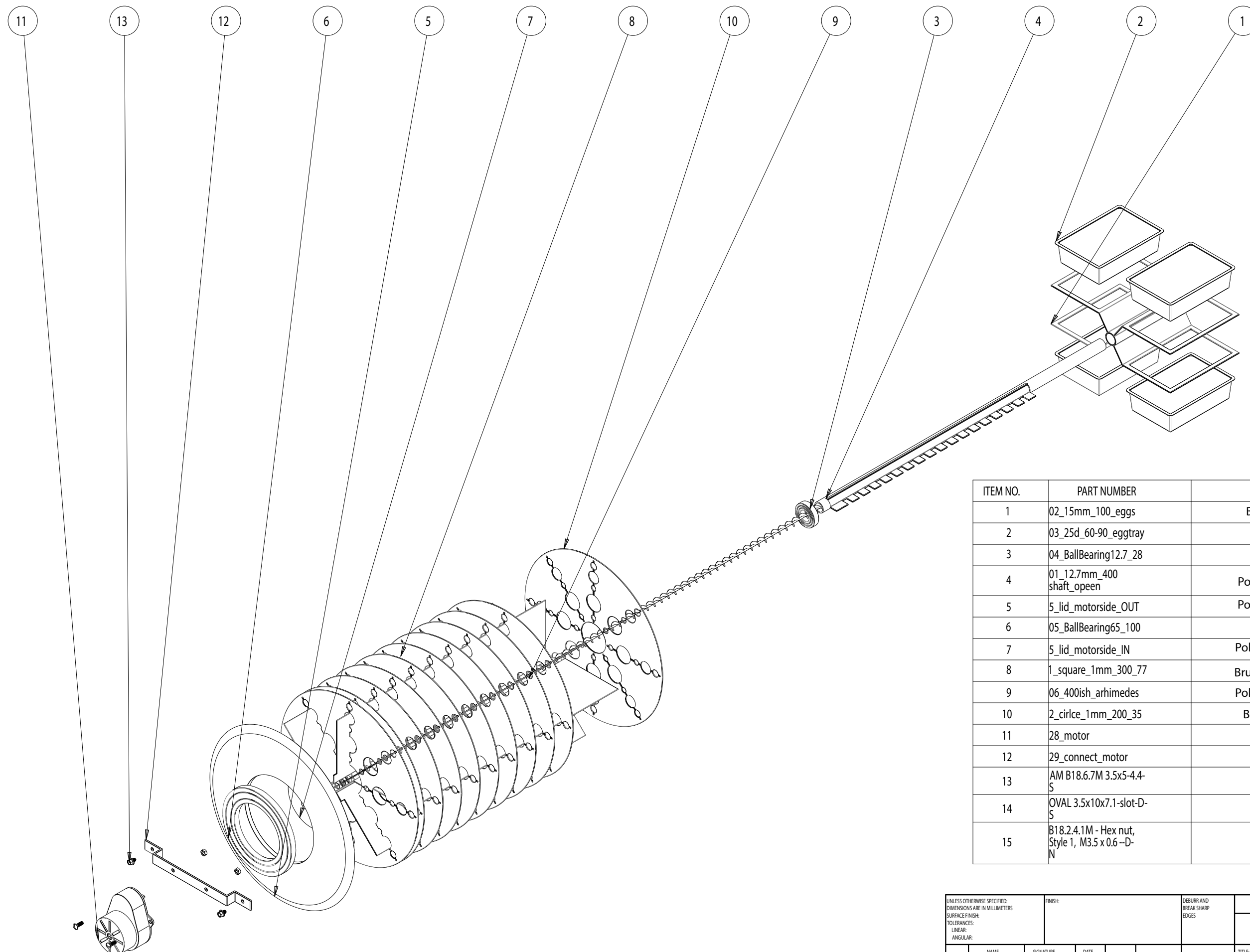
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH TOLERANCES: LINEAR ANGULAR		REVISIONS	DATE	13
NAME	SIGNATURE	DATE	TITLE	

Simple exploded view of a unit farm



Exploded view of a unit farm, no casing





ITEM NO.	PART NUMBER	MATERIAL	QTY.
1	02_15mm_100_eggs	Brushed Aluminium	1
2	03_25d_60-90_eggtray	Polystyrene	4
3	04_BallBearing12.7_28	Steel	1
4	01_12.7mm_400 shaft_open	Polished Aluminium	1
5	5_lid_motorside_OUT	Polished Aluminium	1
6	05_BallBearing65_100	Steel	1
7	5_lid_motorside_IN	Polished Aluminium	1
8	1_square_1mm_300_77	Brushed Aluminium	8
9	06_400ish_arhimedes	Polished Aluminium	1
10	2_circlce_1mm_200_35	Brushed Aluminium	11
11	28_motor		1
12	29_connect_motor	Steel	1
13	AM B18.6.7M 3.5x5-4.4-S	Steel	2
14	OVAL 3.5x10x7.1-slot-D-S	Steel	2
15	B18.2.4.1M - Hex nut, Style 1, M3.5 x 0.6 --D-N	Steel	2

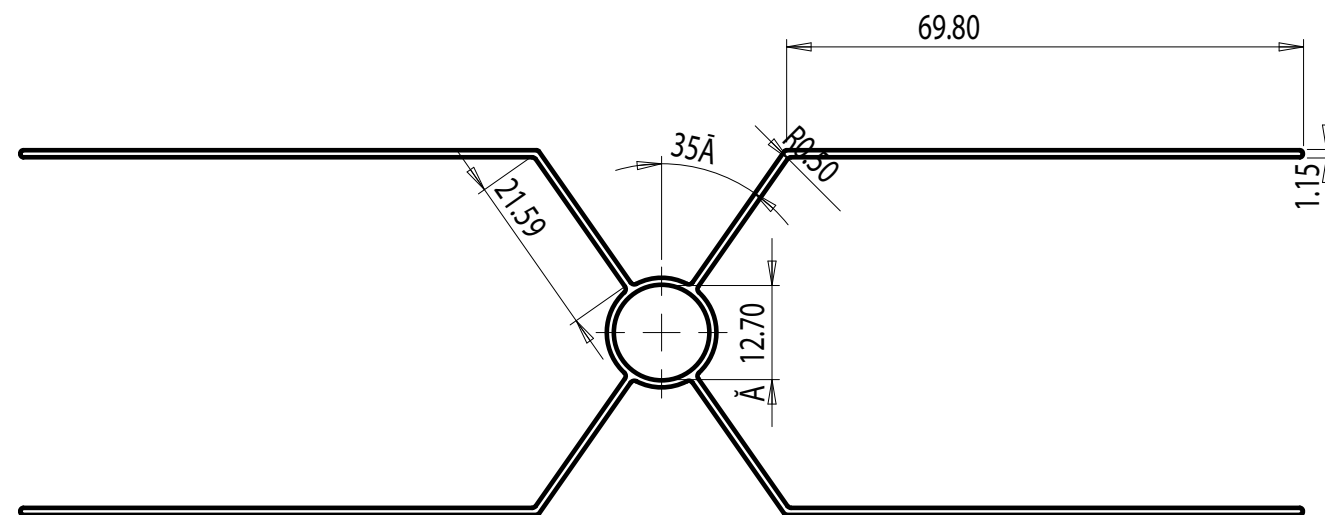
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:				FINISH:		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
								TITLE:			
NAME	SIGNATURE	DATE									
DRAWN											
CHK'D											
APP'VD											
MFG											
QA						MATERIAL:		DWG NO.		A2	
								Unit Farm Insides			

F	
E	
D	
C	
B	
A	

F
E
D
C
B
A

F

A



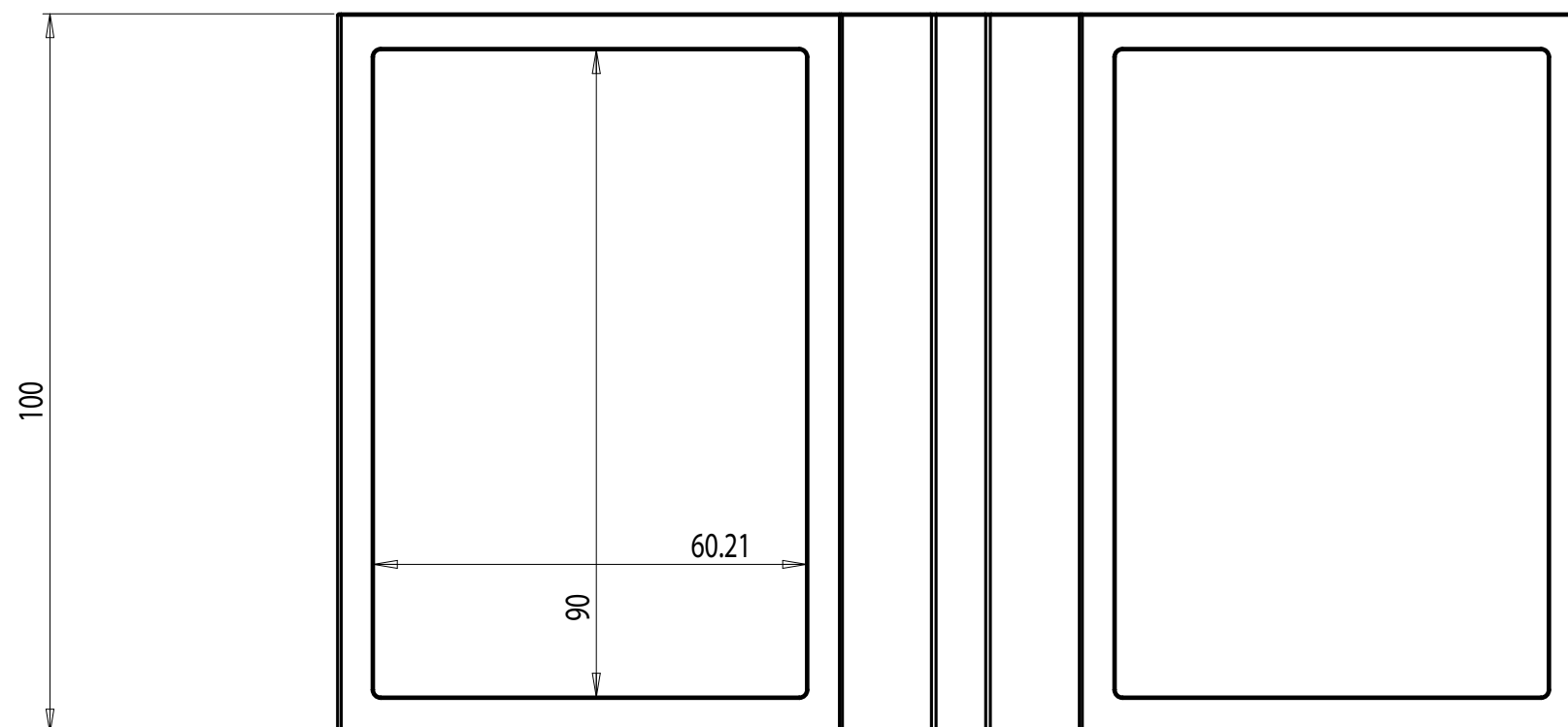
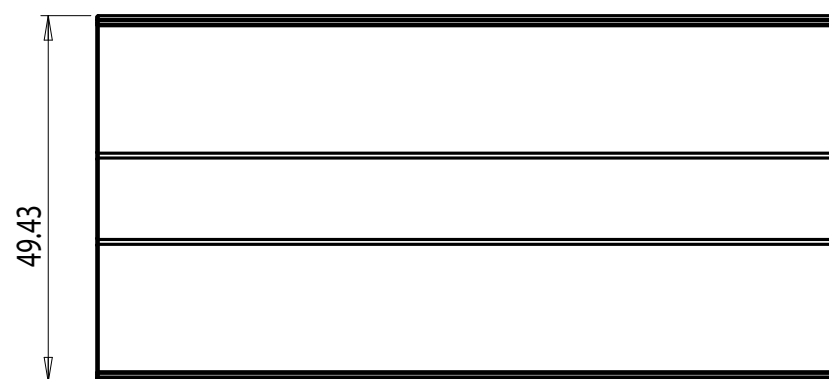
Aluminium extrusion and cutting

+/-Tolerance 0.2 mm, 0.5°

or

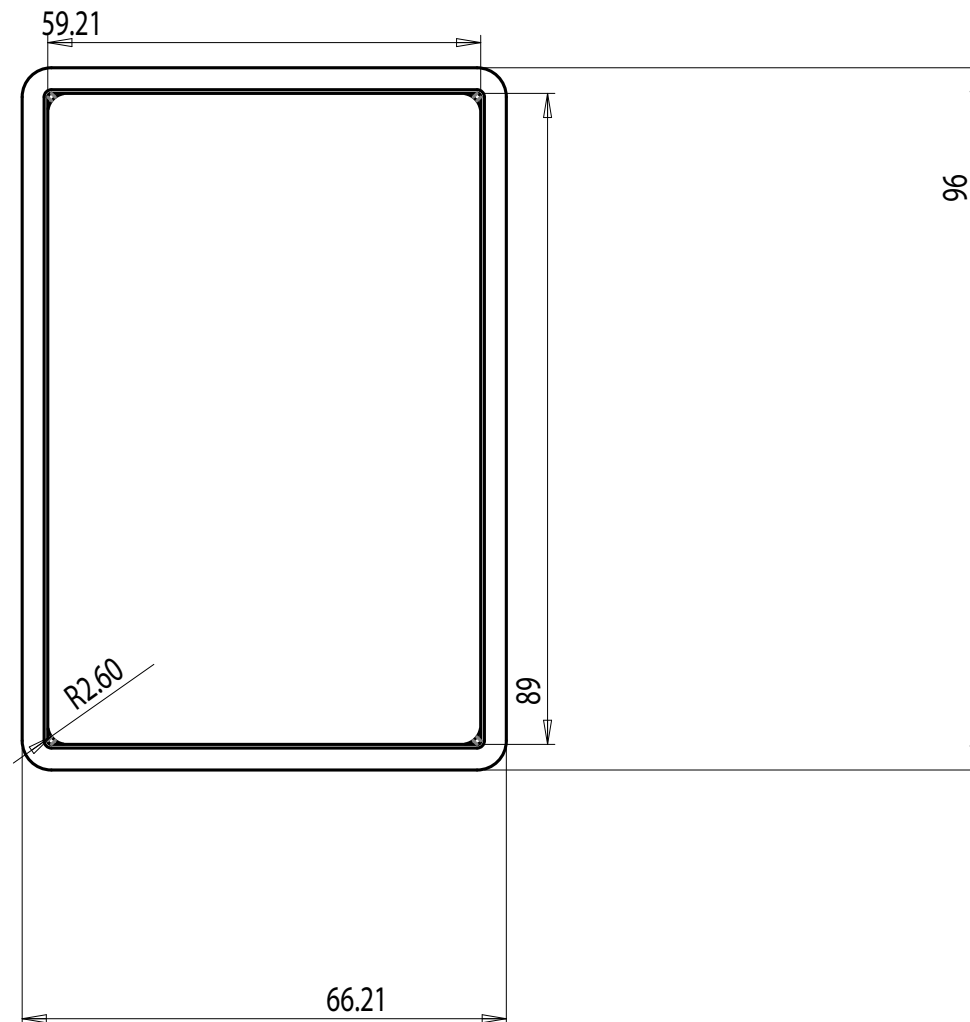
Aluminium tube + sheet cutting, bending and welding

+/- Tolerance 0.5mm, 2°

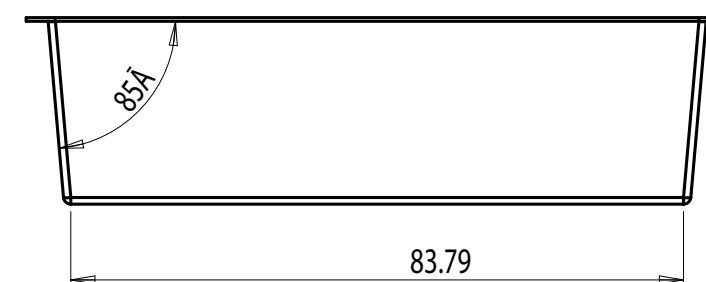
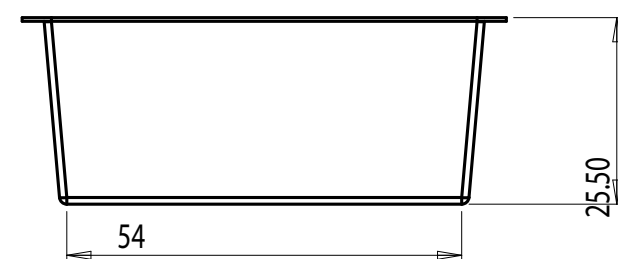


02_15mm_100_eggs

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS				FINISH:		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
SURFACE FINISH:											
TOLERANCES:											
LINEAR:											
ANGULAR:											
	NAME	SIGNATURE	DATE			TITLE:					
DRAWN											
CHK'D											
APP'D											
MFG											
QA											
						MATERIAL:				DWG NO.	
										02_15mm_100_eggs	
						WEIGHT:				SCALE:1:2	
										SHEET 1 OF 1	

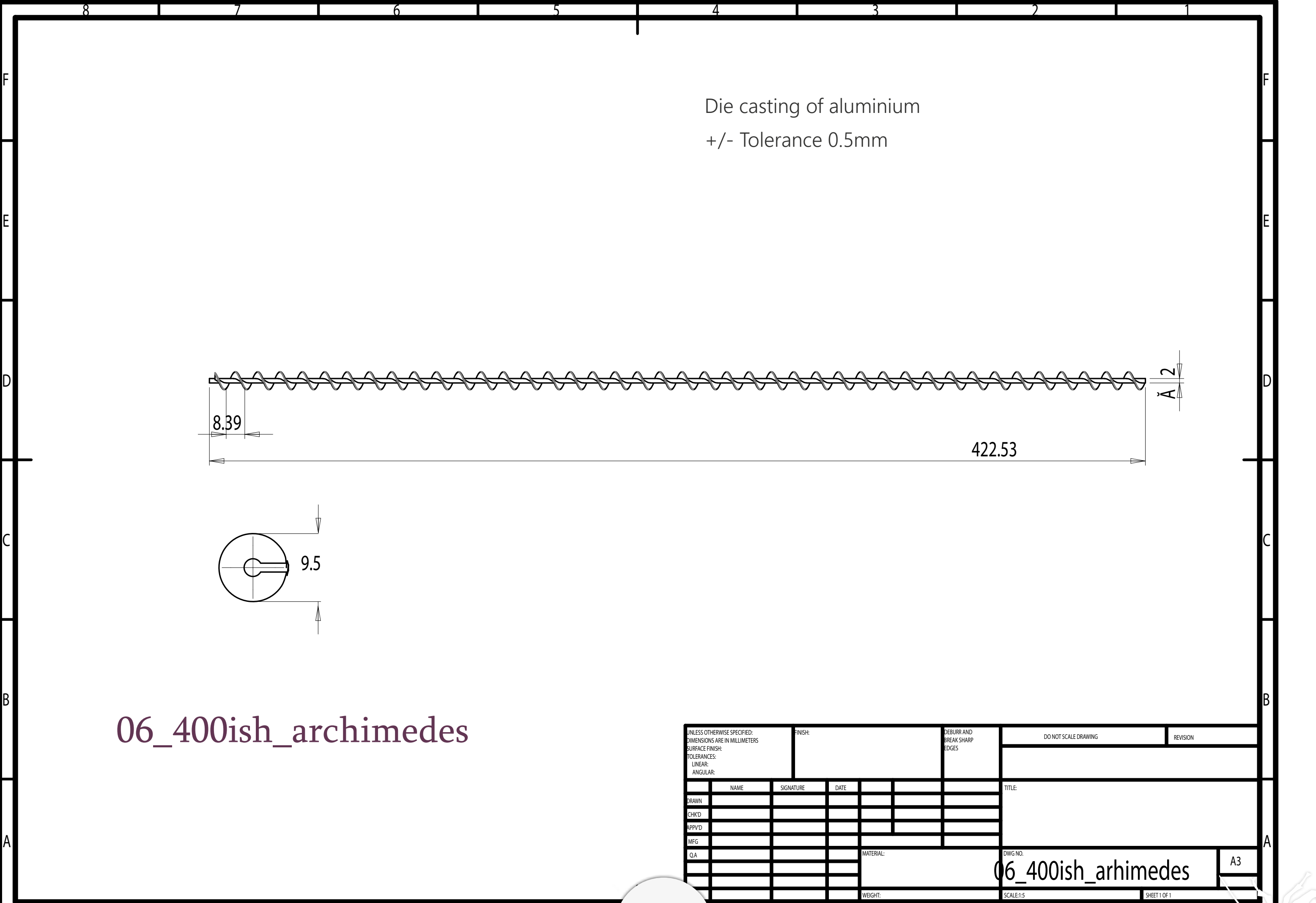


Polystyrene vacuum forming
+/- Tolerance 1mm, 2°

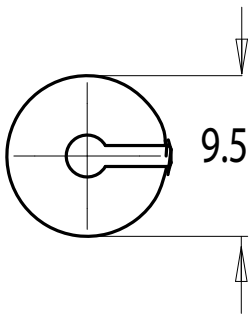
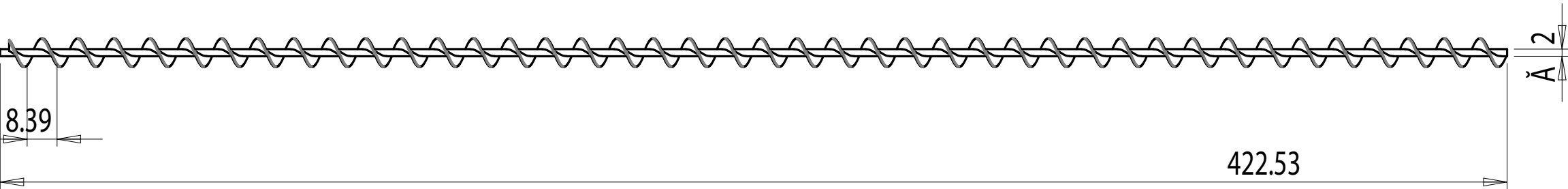


03_25d_60-90_eggtray

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:				FINISH:		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
		NAME		SIGNATURE		DATE				TITLE:	
DRAWN											
CHKD											
APP'VD											
MFG											
QA											
				MATERIAL:				DWG NO.			
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								A3			
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								SHEET 1 OF 1			



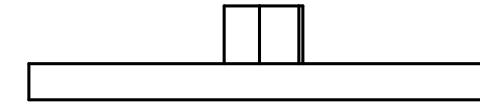
Die casting of aluminium
+/- Tolerance 0.5mm



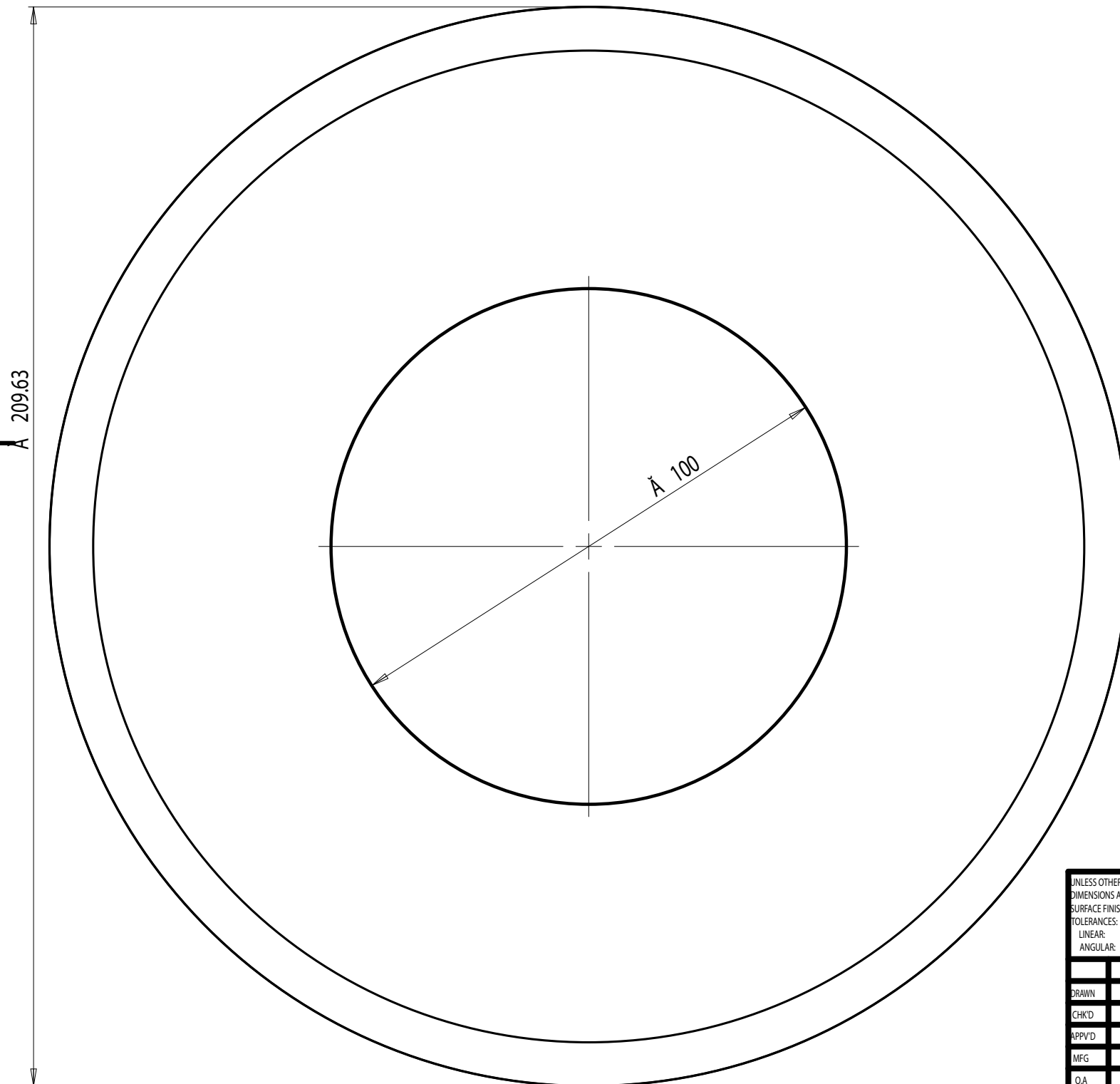
06_400ish_archimedes

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:		FINISH:		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
DRAWN		SIGNATURE		DATE		TITLE:			
CHK'D									
APPV'D									
MFG									
QA						MATERIAL:		DWG NO.	
								06_400ish_arhimedes	
								A3	
						WEIGHT:		SCALE:1:5	
								SHEET 1 OF 1	

5_lid_motorside_IN



+/-Tolerance 0.2 mm



Gergana Tatarova MEng



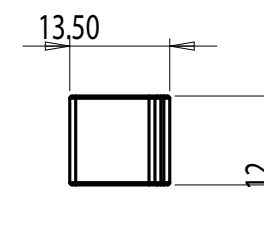
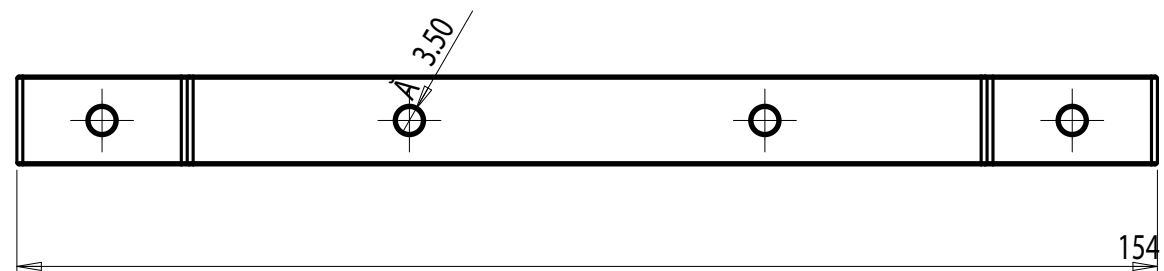
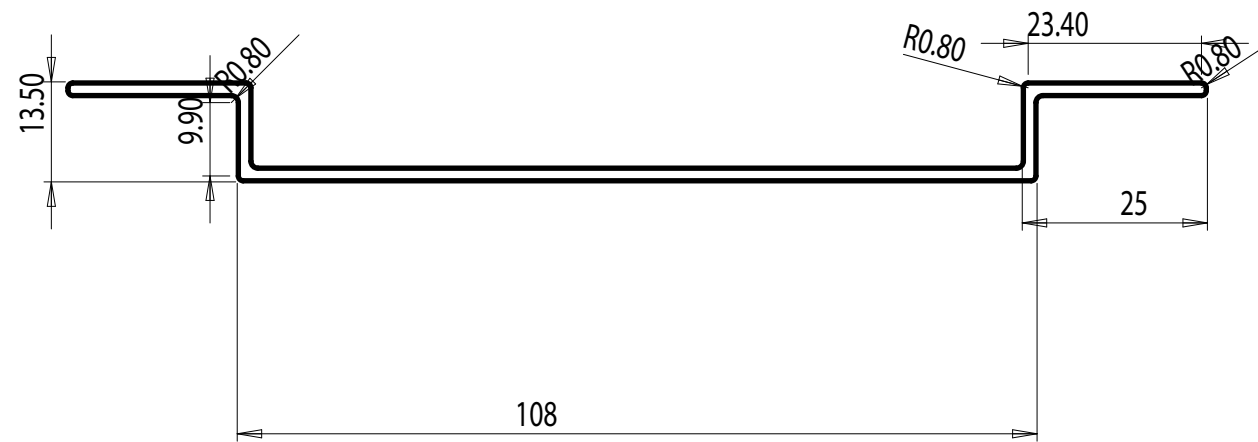
Prefabricated



Gergana Tatarova MEng

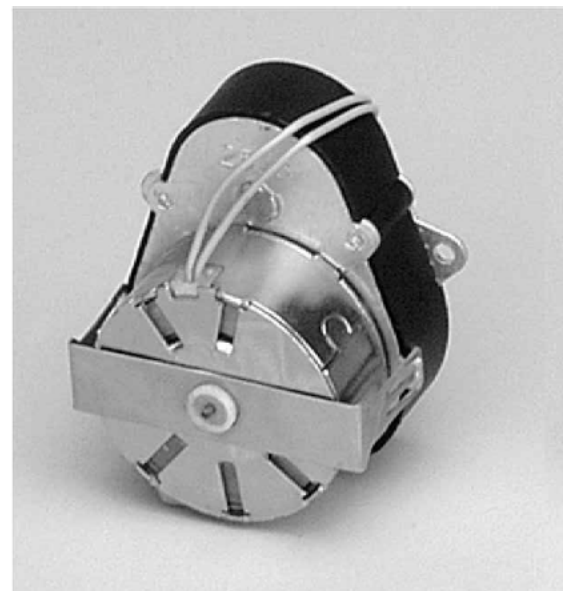
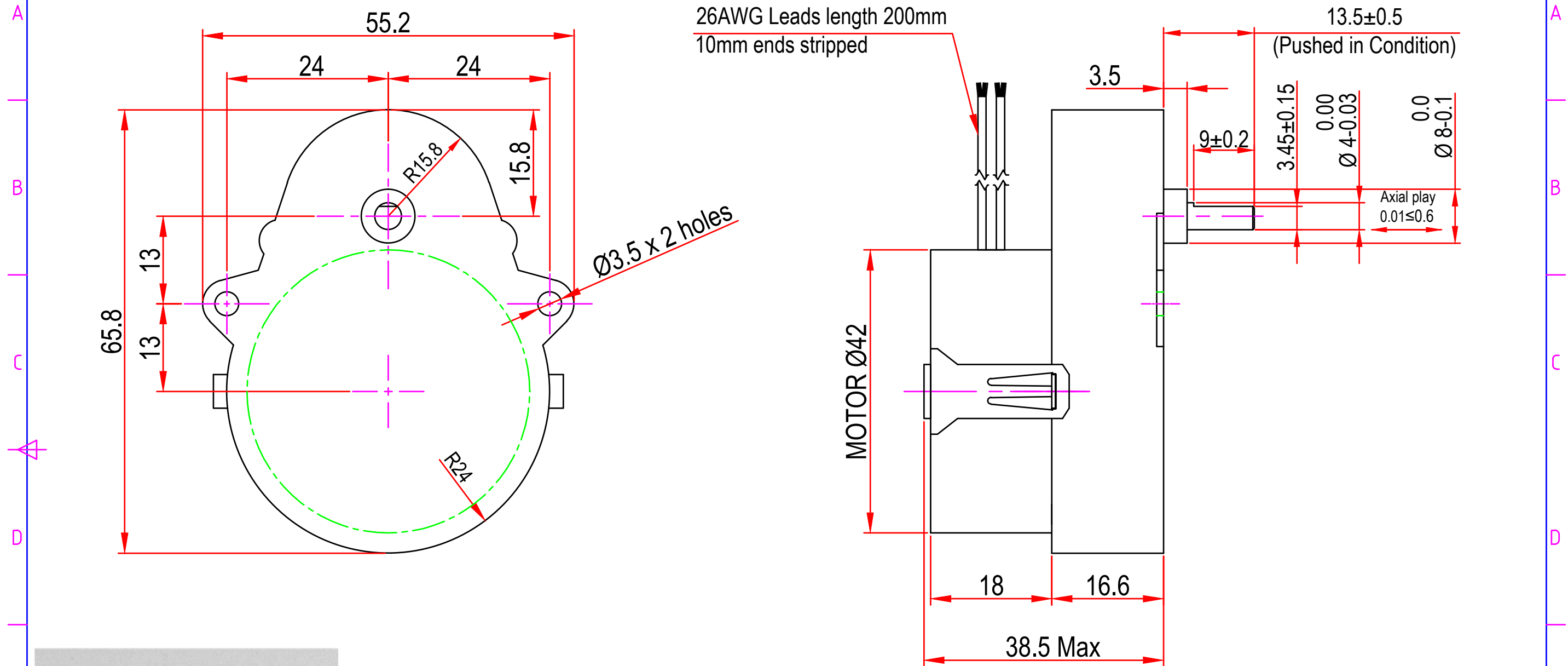
29_connect_motor

steel braket



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:				FINISH:		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
		NAME		SIGNATURE		DATE				TITLE:	
DRAWN											
CHK'D											
APP'VD											
MFG											
QA						MATERIAL:		DWG NO. 29_connect_motor		A3	
						WEIGHT:		SCALE:1:2		SHEET 1 OF 1	

Issue/RevNo	Revision note	Date	Signature	Checked
1.0	Original Issue	01/04/2014	MBM	TNB



28_connect_motor

from sipplier

		 Motion Drivetronics Pvt Ltd	
Itemref		MT05P	Article No./Reference
Designed by	MBM	Checked by	TNB
Approved by	TNB	Date	01/04/2014
BRAND - MECHTEX Navi Mumbai - 400 709.		Assembly Drawing	
F-MKT-022 VER 3.0		Edition	Sheet 1 of 1

Last words

What more should be done

On the big scale I would like to work a bit on the business model. How would a machine like that be purchased and put in operation. I want to go and talk to potential places that might have it running.

On the small scale - Control. It remains one of my favourite subjects at university, so I wish I went more in depth into how would the machine autonomy be maintained.

Temperature, Feed, Cricket Control.

Contamination free control. I did go into this in the technical bit, but I would like to go deeper :)

Reflection

I knew I will end up here and I still did. What is here? Wishing I had spent more time on this document. I am confident that I did my best throughout the project, pushing it in the directions needed and Nick's guidance was really helpful to know which directions to push it in. But I am a bit scared that I cannot convey the work I did in the way I want to. So yep, if I can redo the whole thing again - put more time on the journal... measure before I cut/